ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. LIII. No. 25. 220 Broadway, New York, June 22, 1905.

TABLE OF CONTENTS

LEADING ARTICLES: Page

The New Westminster Bridge Over the Fraser River, British Columbia (illustrated) 647

The Evolution of the Practice of American Bridge Building; C. C. Schneider, President Am. Soc. C. E. 648

The Use of Superheated Steam on Locomotives (illustrated); H. H. Vaughan 652

Standard Specifications for Locomotive Forgings 659

Counterweights for Large Engines (illustrated); D. S. Jacobus, M. Am. Soc. M. E. 659

The San Pedro, Los Angeles & Salt Lake Railway (illustrated) 662

Henry Sturgis Drinker; The New President of Lehigh University (with portrait) 665

Reinforced Concrete Slab Roofing for a Small Warehouse (illustrated) 665

Annual Convention of the American Railway Master Mechanics' Association 666

EDITORIAL 663

Standards of Construction and Maintenance for the Philippine Government Railways—Ought the Philippine Railway Franchise to be Perpetual?

The Problem of Ventilating the New York Subway and Similar Tunnels 663

LETTERS TO THE EDITOR.—A Suggestion for Turning Hollow Reinforced Concrete Dams Into Power Houses; Howard W. Starr—Concerning the Calculation of Column and Girder Systems; Chas. R. Steiner—Method Adopted for Marking Railway Ties in Queensland (illustrated); W. Pagan—The Connecticut Avenue Concrete Arch Bridge at Washington, D. C.; Joseph Babiczky—Recording and Plotting Contours (illustrated); "Enquirer"—An Early Design for a Concrete Substructure for Railway Track; Jos. A. Shinn 664

ENGINEERING NEWS OF THE WEEK 669

PERSONALS 669

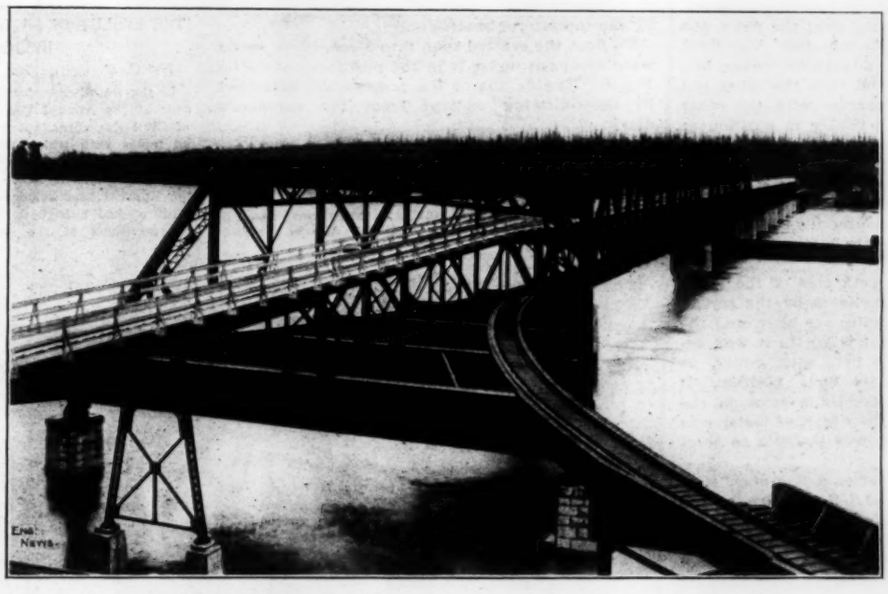
ENGINEERING SOCIETIES 670

THE NEW WESTMINSTER BRIDGE OVER THE FRASER RIVER, BRITISH COLUMBIA.

Superstructure and Erection.

The foundations for the new highway and railway bridge over the Fraser River at New Westminster, British Columbia, were described in detail in Engineering News of June 15, 1905. As noted in that description, these foundations, because of their depth and the methods employed in sinking them, place the structure among the notable bridges of the world. So far as the superstructure is concerned, the bridge is notable chiefly for the special "spread" span designed to accommodate a Y-track and for the methods adopted in erecting the several spans. A diagram elevation of the bridge was given in the previous article; here only the details of the "spread" span and illustrations of the mode of erection are presented. The first page picture is a view of the completed bridge.

GENERAL DESCRIPTION.—The location of the bridge is in the city of New Westminster, B. C., the bridge tangent being placed about where a continuation of Dufferin St. would strike the river bank and at about right angles to the average direction of current. It crosses overhead the track of the Canadian Pacific Ry. on the city side of the river and that of the Great Northern Ry. on the opposite, both tracks being close to the river banks. The structure will carry wagon traffic on an upper deck and steam railway and motor traffic on the lower deck. At a point on the lower deck about 300 ft. from the water's edge on the New Westminster side, or directly over Pier III, the railway track divides, turning to right and left on 12° 30′ curves, thus forming a Y. On this account, the shore span, while only 19 ft. wide between centers of pedestals over Pier III, is about 136 ft. wide between pedestals over Pier II.



BRIDGE ACROSS THE FRASER RIVER AT NEW WESTMINSTER, BRITISH COLUMBIA.

Beginning at Pier II and proceeding toward the south bank of the river, there are the following spans: One through fixed span of 225 ft.; one through fixed span of 380 ft.; one through swing span of 380 ft., and five through fixed spans of 159 ft. each. Next there is a wooden trestle carrying separately highway, railway and motor traffic, and extending across the Great Northern Railway track. Beginning at Pier II and proceeding toward the north or New Westminster bank of the river, there are the following spans: East arm of Y: two deck plate girder skew spans of 75 ft. each, one-half through skew span of 48 ft., and one deck plate girder skew span of 68 ft. West arm of Y: one deck plate girder skew span of 75 ft., one similar span of 48 ft., one-half through plate girder skew span of 25½ ft., and one deck plate girder skew span of 40 ft. Highway structure: one deck plate girder span of 96 ft., and two of 40 ft. each.

Steel bents are used to support all railway spans that cross the railroad track and for the three highway spans at the north end of structure; otherwise all spans are supported on masonry or concrete piers and abutments. The clear roadway for both the railway and the highway is 16 ft., thus making the perpendicular distance between central planes of trusses 19 ft. for the 380-ft. spans and 18 ft. for the 159-ft. spans. The five 159-ft. spans carry the highway above the top chords, while the three longer spans carry it about mid-height of trusses. The motor track joins the railway track of the west arm of the Y on the embankment, and runs over the railway until the wooden trestle is reached, where it diverges to the west and runs parallel to it until the embankment is reached. The highway track does not cover the railway track until just before it reaches Pier III, and it leaves it again when it comes to the wooden trestle; there it turns to the east so as to parallel the railway on a descending grade. It crosses the Great Northern Ry. track overhead, and soon after reaches the earth embankment. The railway and motor floors consist of the ordinary timber ties and guards carrying 75-lb. rails, all as shown on the drawings. The highway floor consists of longitudinal wooden joists carrying a tight double thickness of plank flooring, the lower thickness running diagonally and the upper transversely of the span. Of the main structure the 159-ft. spans have riveted connections; the others are all pin-connected.

SPREAD SPAN.—The spread span between piers II and III calls for some special notice. As already stated, the trusses of this span are 19 ft. apart at one end and 136 ft. apart at the other end. Fig. 1 is a detail of one of the trusses showing the strains in the various members and the sections adopted to withstand them. Fig. 2 is a half plan of the upper lateral bracing between trusses and Fig. 3 is a similar plan of the upper lateral bracing. These drawings are complete and call for no further explanation. The floor construction is shown by the drawings of Fig. 4. As will be seen the bottoms of all vertical posts are dropped below the bottom chords in order to receive the ends of the cross-girders. These are either plate or box girders and are of varying depths according to their lengths. Their exact dimensions are shown by the drawings. The longitudinal girders carrying the tracks rivet into the cross-girders and the latter also carry the bents which support the highway floor. The details of the bracing between the track girders are shown clearly by the drawings. The material used in the spread span and throughout the bridge is medium steel of from 60,000 lbs. to 70,000 lbs. ultimate strength, and the requirements for testing, workmanship, etc., were those of Mr. J. A. L. Waddell's well-known specifications.

ERECTION.—The erection of the superstructure calls for particular mention in respect to the spread span and the 380-ft. fixed span only. These spans were floated into position from falseworks on which they had been erected complete. The swing span and the five 159-ft. fixed spans were erected on falseworks between the permanent piers, but this method could not be readily adopted for the remaining two spans because of the depth of water between piers II. and IV.

Considering first the 380-ft. fixed span, it will be noted that it is of exactly the same length as the swing span which it was designed to erect on falseworks. This made it possible to erect both spans on the same falseworks, erecting the fixed

span first and then floating it off and to its permanent position to give room for the erection of the swing span. To provide for floating off the fixed span the falseworks were made with four openings wide enough to admit four scows. These scows were floated into position at low tide, 6 a. m., Nov 11, 1903, and as soon as they were placed, work was begun pumping out the water that had been admitted to partially submerge them. At 9:20 a. m. the span was lifted clear of the falseworks and at 9:40 a. m. two tugs started to tow it upstream. As soon as the span had been towed clear of the falsework it was gradually moved transversely across the stream until it was opposite its permanent supports, piers III. and IV. It was then dropped down stream between the piers. At 10:20 a. m. the span stood over the piers, the moving having consumed 40 minutes. The fixed end was first landed by admitting water into the scows near that end, and then the roller end was landed by a similar process with the other two scows. The span was finally in position at 2:30 p. m.; the metal work of the span weighed 788 tons and the load carried by the scows was 825 tons, not including the supporting scows and bents. The view, Fig. 5, shows the spans being floated into position and explains the arrangement of the scows and of the trestle bents carrying the span.

As the current on the north side of the river, under the position to be occupied by the spread span, runs at from 4 to 5 miles per hour, and the depth of water at this point is 80 ft., it was decided that the span could not, with safety, be erected on falsework in its final position. It was therefore planned to erect the span on the south side of river where the depth of water was about 25 ft., and where it was possible to erect substantial falseworks.

The first truss was erected on a line parallel to one of the previously erected 159-ft. spans, on the down-stream side and 12 ft. away. The steel for the truss was brought out over the highway roadway and then handled by a single mast derrick having three booms. The heaviest piece handled was a section of top chord weighing 13½ tons. The derrick when handling loads was held down by cast steel anchor hooks catching under the top chords of the 159-ft. spans.

When the first truss was coupled up, preparations were begun for moving it to temporary pile piers which had been driven to receive it. These piers, together with a double intermediate bent, were carefully located with reference to the line upon which the truss had been erected. The intermediate bent was not only to support the truss, but was built so wide that from it batter braces were run to the top chord to hold the truss against overturning. In addition to the braces the truss was held upright by four sets of triple blocks running from the hip points, two from each side of truss, those from up-stream side running to the steel work of the 159-ft. span, and those from down-stream side running to two pile dolphins.

The two scows, each 30 × 90 × 8 ft., into which 2 ft. of water had been admitted, were placed under the truss at low tide. As soon as they were correctly set, eight diaphragm pumps, four to each scow, were started and the water was removed as quickly as possible. The scows were placed under at 5.30 a. m. and the truss was landed at 12 m. The landing was hastened by the admission of water to the scows. The truss, as it was floated, weighed 235 tons. The tension members and substruts, which were subjected to a compression stress due to the position of scows while floating, were stiffened to take the load.

After floating the first truss, the second was erected in the position formerly occupied by the first one, and the two were connected by the floor beams at the narrow end of the span and by the top lateral bracing.

To float the erected span into place, three scows were arranged under it in the positions shown by Fig. 6. The details of the process are explained by the following excerpt from the engineer's diary:

March 19, 1904.—Moved spread span this morning. The three scows were placed in position at 2 a. m., low tide occurring shortly after that time. Three (3) feet of water was admitted to each scow yesterday. The removal of this water was begun as soon as the scows were in place. There were five diaphragm pumps in each scow. At 5.15 a. m. the span was clear of its bearings. At 7.45 the moving of the span was begun and at 9.40 a. m. the span was over its piers. At 11.50 a. m. the four shoes were landed. The scows were removed later in the afternoon at low tide. Water admitted into scows to hasten the landing.

The weight of the span as it was floated into position was 500 tons. The appearance of the span afloat is shown clearly by Fig. 6. The two scows at the wide end were each 30 × 90 × 8 ft., and the scow at the narrow end was 30 × 106 × 8 ft.

After the span had been seated on the piers, there remained to be erected the heavy floor girders and the stringers connecting them. The view, Fig. 7, shows this work in progress, the traveler shown being used to place the [illegible] and lower laterals. Counting from the [illegible] of the span the floor girders in order [illegible] tons, 77 tons, 55 tons, and 31 tons, respectively. They were all erected on falseworks of [illegible] type shown in the view.

As stated in the previous article, the [illegible] for the superstructure was the Dominion [illegible] Co., of Montreal, Canada. This company [illegible] the erection work described. Mr. M. W. Jull[illegible] being the foreman in direct charge. The engineers of the bridge were Waddell & Hedrick, of [illegible]nsas City, Mo. We are indebted to Harry K. Seltzer, their Resident Engineer, for the information from which this account of its construction has been prepared.

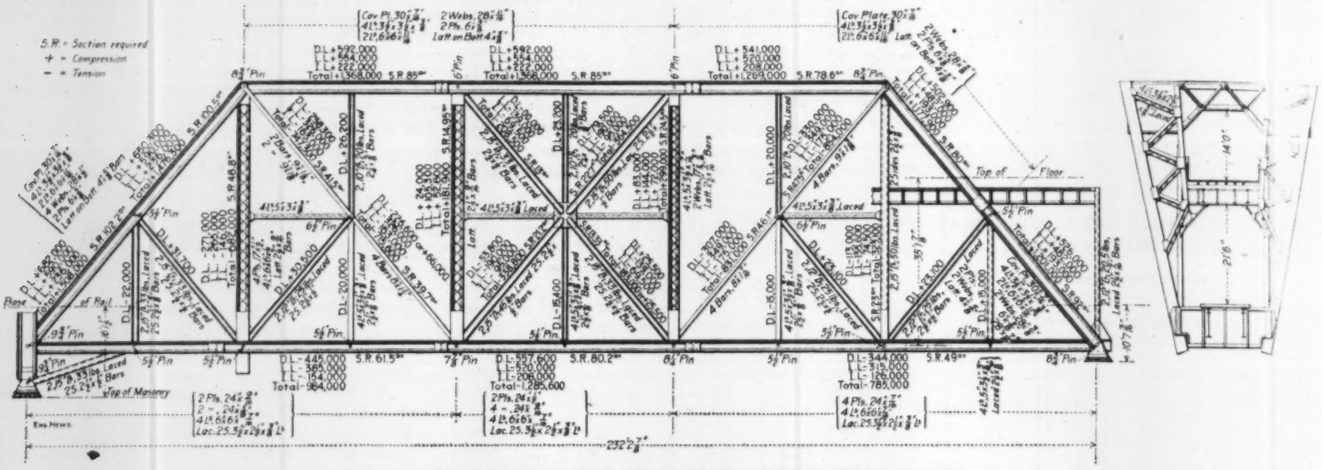
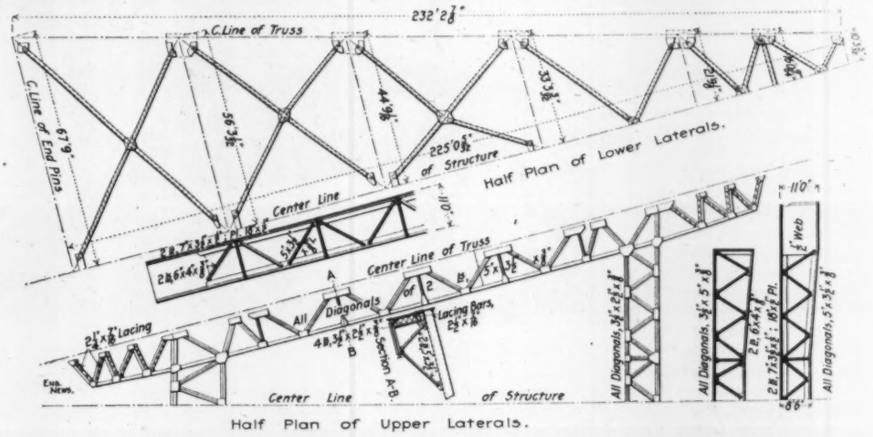


FIG. 1. DETAILS OF SPREAD SPAN TRUSS, FRASER RIVER BRIDGE.



FIGS. 2 AND 3. UPPER AND LOWER LATERAL BRACING FOR SPREAD SPANS.

THE EVOLUTION OF THE PRACTICE OF AMERICAN BRIDGE BUILDING.*

By C. C. Schneider, President, Am. Soc. C. E.

In the time-honored custom of an address by the President at the Annual Convention of the American Society of Civil Engineers, many of my predecessors have selected topics with which they were most familiar. My life work naturally suggests to me the title of this address.

The magnificent stone bridges and aqueducts built by the Romans bear evidence that the art of bridge building had reached a high degree of perfection among the ancients. Some of the early Roman structures were of gigantic proportions, and have not been excelled by any of those built in modern times. There are no records to show that the ancients had any theoretical knowledge of bridge construction; they built their bridges in accordance with empirical rules developed by experience. These monuments of engineering skill, which have lasted for thousands of years appear marvelous to the modern engineer, who has at his command, not only theoretical knowledge, but also mechanical appliances and modern tools to assist him, which were not known in ancient times. The progress, therefore, made in the art of constructing bridges of stone in modern times [illegible]

*Presidential address before the American Society of Civil Engineers at the Annual Convention at Cleveland, Ohio, June 20, 1905.

pears significant, and is practically confined to theoretical knowledge and improvements in machinery and tools for handling material.

The development of the art of bridge construction is marked to a certain extent by periods coincident either with the introduction of new materials or with the necessities arising for means of transportation. The marvelous progress made in bridge building in the 19th century—the century of engineering, of the manufacture of power, of the railroad and the telegraph—really began with the production of wrought iron in large quantities, and has since kept pace with the development and progress made in the manufacture of those most useful and precious of all metals, wrought iron and steel.

The various types of bridges which have survived and become the standard types of the present day are the results of the evolution of a century, originating with the wooden bridge, the wooden beam being the prototype of the modern plate girder, and the framed wooden truss that of the steel truss. Timber bridges, consisting of hewed logs, supported by piers of piling or of stone, were erected in the earliest times in all countries where timber was abundant, Caesar's bridge across the Rhine was of this character. The wooden bridge consisting of framed trusses is the product of more modern times.

In Europe, wooden truss bridges of small span, patterned after existing roof trusses, have been built for several centuries. In America, however, it was not until the end of the 18th century that the movement began to which the present type of bridges can be traced.

There appear to be no records of any wooden bridges in America before 1785, when unusually gifted men like Palmer, Burr, Wernwag and others commenced to build some very remarkable wooden structures. The progress made in bridge building in this country was very slow until railroad building commenced, which was in 1829, when the construction of the Baltimore and Ohio Railroad was begun. The first wooden railroad bridge was built on that road in 1830 by Wernwag, at Monaguay. The development of railroads naturally created a demand for bridges.

The difficulties and obstacles encountered in crossing long and deep valleys were overcome by these pioneer railroad builders by erecting temporary timber trestles in place of expensive embankments or viaducts, to be filled in or rebuilt by permanent structures at a later period. The timber trestle, therefore, is a distinctly American type of construction, and is the prototype of the iron viaduct. Some of the first high wooden trestles were built in 1840 on the Lake Schuylkill and Susquehanna Railroad, now the Catawissa Branch of the Philadelphia and Reading Railroad. They were designed by James F. Smith, and their heights varied from 60 to 130 ft.

The forms of timber trusses of different kinds, arches and combinations of two or more systems, have been very numerous. A marked step toward bridge designs of the modern truss form was the lattice bridge patented by Towne in 1820, which became the prototype of the early iron lattice bridge. The next important step in the development of wooden bridges was made in 1840, when Howe patented his truss, which became very popular and the standard for wooden railroad bridges. In 1844, the Pratt truss was patented, which afterward became the favored type for iron bridges. Many other types of trusses were invented, which have since been discarded.

The earliest wooden bridges were built by expert carpenters. The work was done by contract, very much the same as building work is done at the present day, except that the builder was also the designer. The builder would buy suitable timber or have it sawed to order at conveniently located saw-mills, and any ironwork needed in the construction of the bridge, such as rods, bolts or bars, he would obtain at a local blacksmith shop, and frame and erect the bridge in place, ready for traffic. The same methods were also used in building the early iron highway bridges. Each of these builders had his own type of bridge and his own special details. At that time there was generally but little competition, as very few had any knowledge of bridge building, and each one controlled a certain territory.

All the early railroad bridges were wooden structures built by practical carpenters, in most cases employees of the railroad company.

England is considered as the pioneer country of the iron bridge, the first one, consisting of a nearly semicircular cast-iron arch, having been built in 1776-79. In 1786, Thomas Paine, the well-known author, designed and made a model of a segmental arch. This model was set up at Franklin's house in Philadelphia, whence it was taken to the State House, and, eventually, was sent to Paris and exhibited at the Academy of Sciences. Paine had an experimental cast-iron bridge built in England in 1790, and Rowland Burdon, in 1793 to 1796, built the bridge at Wearmouth, of 240 ft. clear span, after this model, which formed the basis of many cast-iron bridges built thereafter, and became the prototype of the modern steel arch. Paine's device was also the basis of the design of the Market Street Bridge and the first Fairmount Bridge, in Philadelphia, both being wooden arches. The former was completed in 1800, and the latter in 1812.

Up to 1840, there were no iron bridges in this country, except suspension bridges in which iron links were used in the cables and suspenders, the floor-system being of wood. The first bridge in America consisting of iron throughout was built in 1840 by Earl Trumbull over the Erie Canal, in the Village of Frankfort, N. Y. In the same year Squire Whipple, Hon. M. Am. Soc. C. E., also built his first iron truss bridge.

Probably the first iron railroad bridge was built on the Philadelphia and Reading Railroad at Manayunk by Richard B. Osborne, Chief Engineer, in 1845. It was a double-track through bridge, of 34 ft. clear span, of the Howe truss type, with cast-iron top chord and web braces, the bottom chord and vertical web members being of wrought iron. This bridge was followed by several others of the same type.

The earlier wooden and iron bridges were built very much in the same manner as the ancient Roman bridges, in accordance with empirical rules, by practical men who had no accurate knowledge of the strains produced on the various members of a structure by the exterior forces, but who were men of unusual constructive ability and

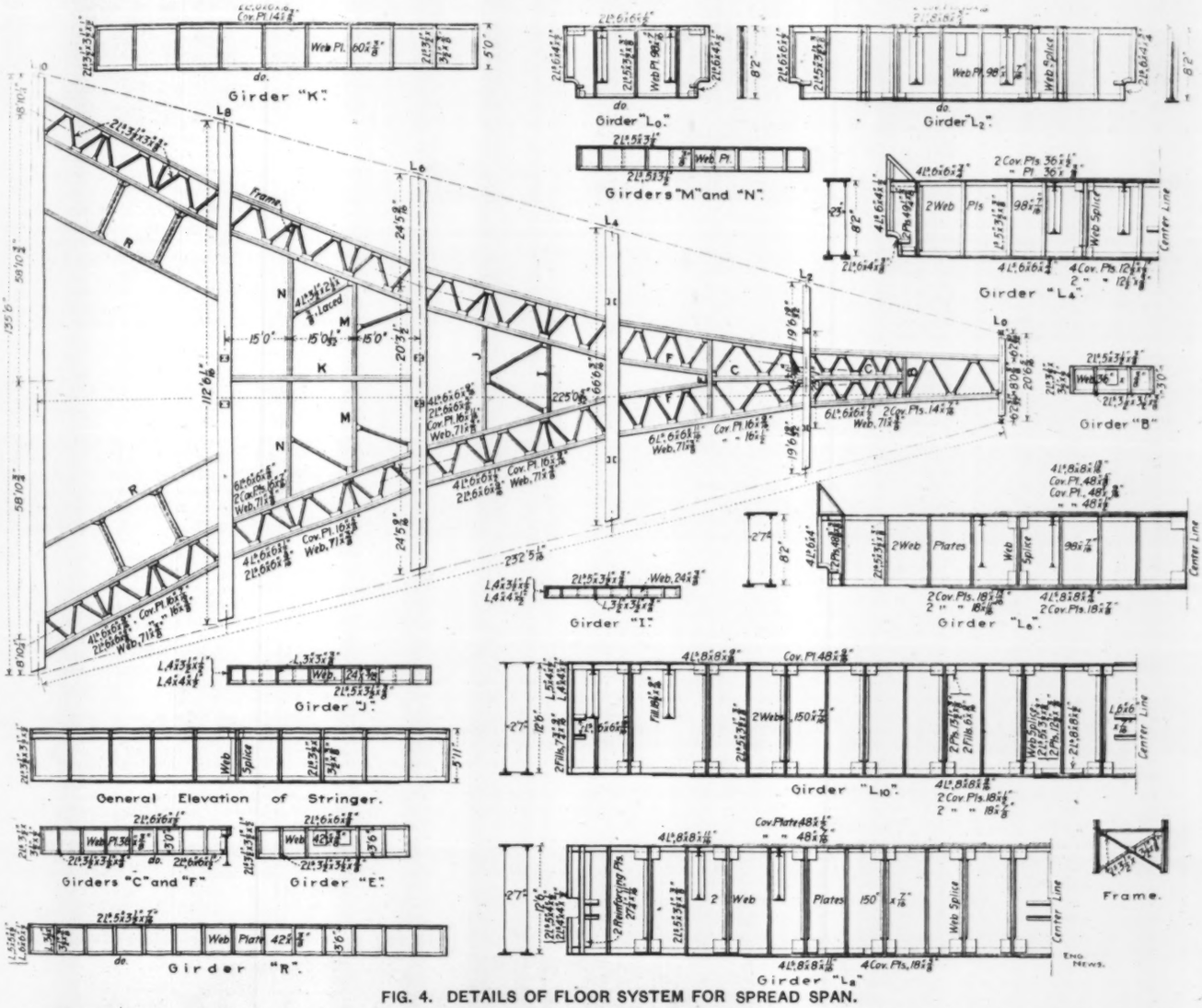


FIG. 4. DETAILS OF FLOOR SYSTEM FOR SPREAD SPAN.

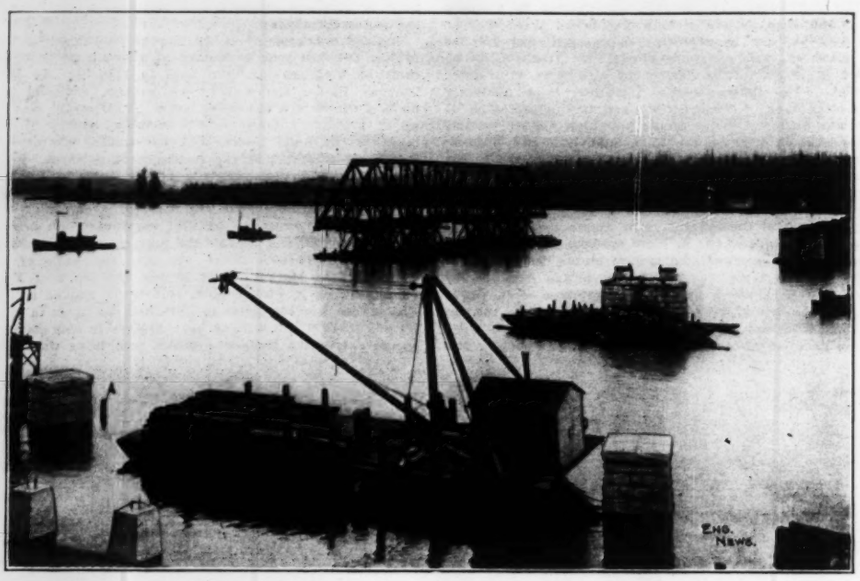


FIG. 5. VIEW SHOWING 380-FT. SPAN BEING FLOATED INTO PLACE ON BARGES.

sound judgment, who had to depend upon their own resources and natural instinct, experimenting with models and profiting by previous failures. Pratice always preceded the science, thus the structural systems were invented before their theory was developed.

Until 1847, when Squire Whipple, the modest mathematical instrument maker, who, without precedent or example, evolved the scientific basis of bridge building in America, correct methods of computing the strains in framed structures were not known. A few years later, in 1851, Herman Haupt published a book on the theory of bridge construction.

About 1850, after the building of railroads had advanced, the educated engineer commenced to exert his influence in the art of bridge building, and, from that time forward, steady progress was made. The period from 1850 to 1860, therefore, may be regarded as an epoch in the history of American bridge building; the time when the bridges designed by Fink and Bollman first came into use, and the earliest iron Whipple and Pratt trusses were built.

When American engineers commenced to build iron bridges, they paid little attention to the then existing European models, but preferred to develop their own systems independently, as they had done previously with wooden bridges, the first iron bridges being imitations of the Towne lattice, and the Howe and Pratt trusses. All the earlier bridges were built principally of cast iron, wrought iron being used in tension members only. In the first iron viaduct built by the Baltimore and Ohio Railroad, in 1852, all parts were of cast iron, except the tie-rods. The wrought-iron tension members at that time usually consisted of round bars with screw ends, or elongated links made of square bars. Later, these links developed into forged eye-bars, introduced by J. H. Linville, M. Am. Soc C. E., in 1861. These eye-bars have since become one of the distinctive features in American bridge construction. Although flat eye-bars were used in Europe at an earlier period, in chains of suspension bridges and in some types of trusses, they did not find favor there, and were soon discarded for structures with riveted connections.

The first bridges made entirely of wrought iron were those of the riveted lattice type which Howard Carroll, then Assistant to George E. Gray, Hon. M. Am. Soc. C. E., Chief Engineer of the New York Central Railroad, commenced to build in 1859; next came the plate-girder type, the first of which was built by E. S. Philbrick, M. Am. Soc. C. E., for the Boston and Albany Railroad in 1860.

The bridge built by J. W. Murphy in 1863, over the Lehigh River at Mauch Chunk, for the Lehigh Valley Railroad, was the first pin-connected bridge constructed entirely of wrought iron in its main members; cast iron being used only for joint boxes connecting the compression members. Many bridges of similar construction were built after this, but it was not until after the failure of the Ashtabula Bridge, in 1876, that cast iron was entirely discarded as too unreliable a material to be used in any parts of a railroad bridge.

Prior to 1860, railroad bridges were generally designed by the railroad companies' engineers, the ironwork being manufactured at the companies' shops, and erected by their own forces. Thus, men like Wendell Bollman, Albert Fink, Past-President, Am. Soc. C. E.; C. Shaler Smith, M. Am. Soc. C. E., and C. H. Latrobe, M. Am. Soc. C. E., on the Baltimore and Ohio Railroad; Richard D. Osborn and Charles Macdonald, M. Am. Soc. C. E., on the Philadelphia and Reading Railroad; J. H. Linville, on the Pennsylvania Railroad; E. S. Philbrick, on the Boston and Albany Railroad; George E. Gray, Howard Carroll and Charles Hilton, on the New York Central Railroad; Williard S. Pope, M. Am. Soc. C. E., on the Chicago and Northwestern Railroad; Thomas C. Clarke, Past-President, Am. Soc. C. E., on the Chicago, Burlington and Quincy Railroad; S. S. Post, M. Am. Soc. C. E., on the Erie Railroad, were prominent railroad engineers who took a leading part in early bridge building.

Later, some of the men who had gained experience in framing and erecting bridges, or in the construction of the work at the shops, started in business for themselves, and took contracts to build and erect bridges on designs furnished by the railroad companies' engineers. Most of those early firms were contractors for building Howe truss bridges, only a small shop being required to manufacture the ironwork needed for structures of that class.

Some of the bridge engineers employed on railroads, seeing that they could use their knowledge to better advantage in the more profitable business of contracting, associated themselves with the then existing bridge building firms, or organized new companies. These new companies often made a specialty of manufacturing constructions of a certain type, expressing the individuality of the engineer at their head, and which were his own inventions, in many cases controlled by patents. They were able to furnish designs for bridges, as well as construct and erect them. Most of those companies were organized between 1860 and 1870, which period, therefore, forms another epoch in the history of American bridge building.

Near the end of the 60's, when most of the early bridge companies had been formed, there were, besides the engineers interested in bridge building firms [illegible] experienced bridge engineers in this country [illegible] eers who were at that time connected with [illegible] panies were mostly men who had gained th[illegible] in the employ of some railroad company, ha[illegible] their own type of construction, and had ex[illegible] only in designing, but also in superintend[illegible] struction and erection of bridge work. Th[illegible] knowledge, measured with the present st[illegible] limited to elementary methods, but their th[illegible] tical training enabled them to combine theo[illegible] tice to the best advantage. They under[illegible] make their designs conform to the methods [illegible] shop, as well as to facilitate erection. Thi[illegible] the beginning of the development of Amer[illegible] building and of the distinctly American types [illegible] tion which at that time differed so materially [illegible] of other countries.

The most distinguishing feature of the me[illegible] prevailing in this country, as compared wi[illegible] other countries, the influence of which is felt t[illegible] ent day, is that at that time in America t[illegible] were designed by experienced specialists, and [illegible] was constructed in shops built and equipped [illegible] special purpose by experienced mechanics trai[illegible] class of work. At first these companies con[illegible] work in certain territories, or the contracts we[illegible] to them on account of the reputation of their [illegible] However, as competition became keener, railroa[illegible] to purchase their bridges for the lowest price, and [illegible] several firms or companies to submit tende[illegible] bidders' own designs, which started the compe[illegible] tem of designing and bidding on bridge work.

Up to about 1872, specifications, as we now understand the term, were not in general use. An invitation to bid on bridge work would be accompanied by a survey plan, giving the length of the spans, skews, etc., and a statement of the live load the bridge was to carry, generally a uniform load of 1 ton per linear foot, with a factor of safety of 5. The design of the structure and the proportioning of its members and their details and connections were left entirely to the judgment of the builder, and accepted without question by the purchaser. These builders, who at that time were about the only bridge experts in America, were considered authorities, and would assume the responsibility for the design and the strength of the bridge for the specified loading. In other words, the bridges were accepted on faith and on the strength of the reputation of the builder.

From 1864 to about 1874, the designing of bridges was almost entirely in the hands of the bridge-building firms, only a few railroads, such as the Pennsylvania, and Boston & Albany, employing their own bridge engineers to prepare the designs and to supervise the construction of bridges and other structural work on their respective roads. The contracts for bridges were then let on a lump-sum price for the work erected in place. It was therefore to the interest of the bridge builder to make designs which would reduce the cost of shop work, as well as that of erection, and, as the price of wrought iron was high, as compared with the price of steel at the present time, the saving of material was one of the most important considerations in the designing of bridges.

At that time railroad construction had commenced to develop rapidly in all parts of the country, and many wide and treacherous rivers had to be spanned with bridges. The material for these bridges had to be transported to distant places, erected in unsettled locations, and the ironwork manufactured and erected rapidly in order to keep pace with the swift progress made in the building of railroads. As the pin-connected type ful-

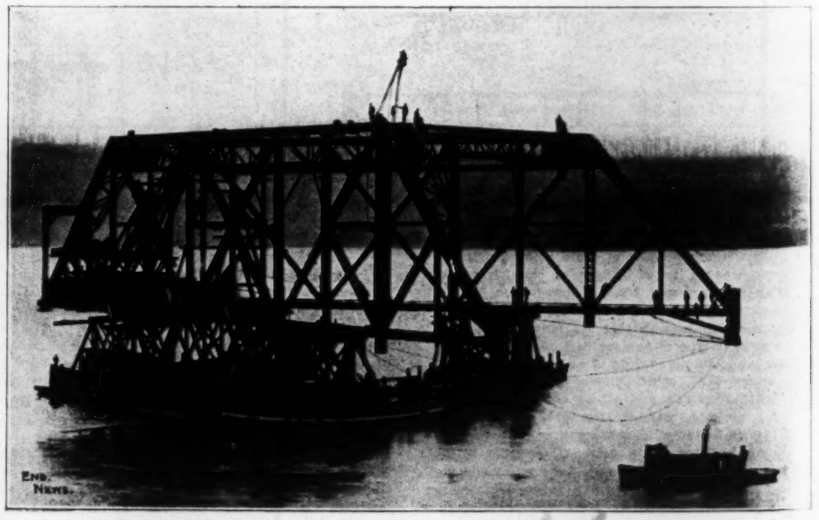


FIG. 6. SPREAD SPAN BEING FLOATED INTO PLACE ON BARGES.

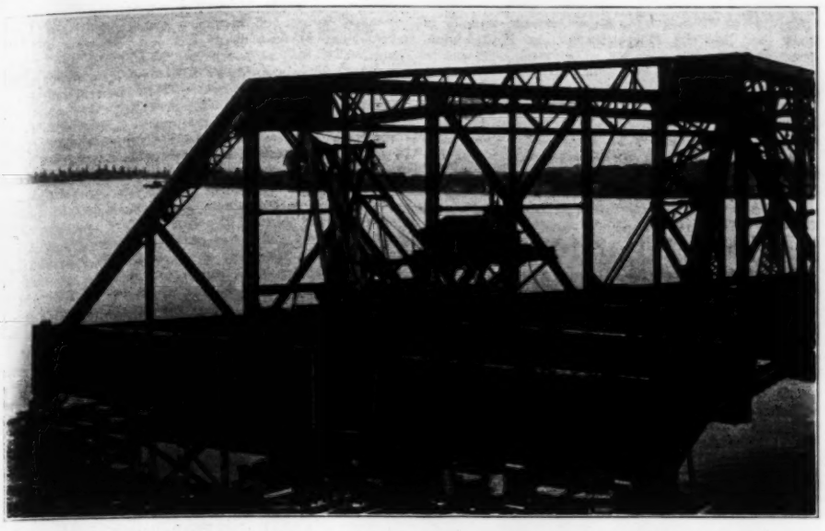


FIG. 7. VIEW SHOWING ERECTION OF FLOOR SYSTEM FOR SPREAD SPAN.

filled, more than any other, these requirements, viz., economy in weight and facility in manufacture and erection, thereby not only reducing the cost, but also the risks and dangers of erection, it became the favorite type of bridge, and has remained so for long spans to the present day.

The first more comprehensive specifications were those published by Clarke, Reeves & Co., in 1871. In 1873, George S. Morison, Past-President, Am. Soc. C. E., prepared specifications for the Erie Railroad, which were probably the first printed specifications for iron bridges adopted by any American railroad. In 1875, L. F. G. Bouscaren, M. Am. Soc. C. E., wrote specifications for the Cincinnati Southern Ry., the first in which concentrated wheel loads were specified for the live load. Mr. Morison established the practise, on the Erie Railroad, of requiring the successful bidder to submit strain sheets and plans for approval before ordering material or commencing work. These plans, before being approved by the chief engineer, were examined by one of the assistant engineers, and, later, the material and workmanship were inspected by men in the employ of the railroad. The same practice was also adopted by Mr. Bouscaren on the Cincinnati Southern Ry.

The year 1873, therefore, may be considered as marking the beginning of another epoch, viz., that of the bridge engineer as again acting in the interests of the railroad company, and also the beginning of the inspection of structural ironwork. Before that date the St. Louis Bridge was probably the only case on the construction of which inspectors of material and workmanship were employed.

Many new bridge companies were established after 1874, some of which had a marked influence in the development of American bridge construction, as well as in the improvement of tools and machinery, resulting in a higher grade of work. Some of the engineers who had gained experience in the employ of bridge companies obtained positions on railroads as bridge engineers; others, particularly the most competent, left the employ of bridge companies for private practice, and devoted themselves to the specialty of structural engineering, acting in the interests of corporations and municipalities or other purchasers of iron structures.

These corporations commenced to realize that it would be to their advantage to have the services and advice of competent specialists. Thus, in 1876, the existence of the bridge engineer and structural expert, independent of a bridge company, had become an established fact.

After iron railroad bridges had been in service for about twenty years, engineers who had charge of their maintenance noticed that weak points developed under traffic, particularly in the details and connections. It also became apparent that the bridges built, up to about 1875, were deficient in rigidity and lateral stability, and improvements were gradually made to remedy these defects, producing more massive construction, fewer and heavier parts, and a more extensive use of riveted connections. The pin-connected type of truss for short spans was gradually discarded, the plate girder and riveted truss taking its place, and the limiting length of spans for these types was gradually increased. Specifications for iron bridges were also revised and improved; those prepared in 1877 by Charles Hilton for the Lake Shore and Michigan Southern, and by C. Shaler Smith for the Chicago, Milwaukee and St. Paul Railroad, and 1879 by Theodore Cooper for the Erie Railroad, being steps in that direction.

Steel, as a structural material was first used in a portion of the St. Louis Bridge, completed in 1874, but the first bridge built entirely of steel was the Glasgow Bridge, over the Missouri River, completed in 1879. The extensive use of steel, however, did not commence until 1890. Before that time steel was used only in isolated cases, or for heavy work, such as chords and eye-bars for large spans.

About 1890, some railroads commenced to build also smaller spans and plate girders of steel, and, for eye-bars, steel was almost exclusively used. At that time most of the rolling mills, which had formerly manufactured wrought iron, were equipped with steel furnaces, but continued for some time to make both kinds of material, until they found it more profitable to confine themselves to the manufacture of structural steel only, and discontinued the manufacture of wrought iron. In 1894, it was practically impossible to obtain wrought iron shapes, and from that time forward steel entirely superseded wrought iron as the modern structural material. The year 1894, therefore, may be considered as the commencement of the present epoch—the steel age.

The use of steel in the construction of modern bridges, and the improvements made in its manufacture, thereby reducing its cost and increasing its reliability, have made it practicable to build structures of a magnitude never attempted before. Its introduction as a structural material had a marked influence on the progress and development of bridge building. Certain types of construction and details which have proved unsatisfactory have been discarded, and others which have undergone a process of purification and improvement have survived. Rational types of construction and details are now established, and have become the recognized standards for ordinary bridges of moderate spans. The present tendency is toward uniformity, and to-day there is but little difference between the designs made by competent engineers.

This tendency toward uniformity has also been extended to specifications for bridges and other steel structures, relating to quality of material, workmanship and unit strains. As late as five years ago, the requirements specified for the quality of steel were numerous, almost every railroad or bridge engineer requiring some different grade, and sometimes several different kinds in different parts of the same structure. Erratic specifications are now gradually disappearing, and engineers at the present time are nearly all agreed on the grade of steel best suited for structural work.

There is also at present more uniformity between the designs made by American engineers and those by European engineers. In the early days of iron bridge building, in this country, there was little resemblance between American and European structures. Each country gradually adopted the good points of the other's practice; we adopted their practice in the use of riveted trusses for longer spans and a more extensive use of riveted connections; while the European engineers are adopting the more rational designs and details of plate-girder and riveted-truss construction now used in America. At the present time, the designs of plate girders and ordinary riveted-truss bridges, made in this country, are almost identical with the designs made by the best bridge engineers in Europe, so that no vital difference now exists between American and European bridges of moderate spans.

The steady increase in the weights of locomotives and rolling stock has been the cause of constant replacements of iron and steel railroad bridges by heavier structures. As the extreme limit of loads may not yet have been reached, the probable future increase should be anticipated in designing new bridges which have to carry any kind of railroad traffic. While it is impracticable to provide for all possible emergencies, railroad bridges should be designed to withstand the ordinary contingencies of traffic, such as derailment, a broken axle or a collision on the bridge. Structures designed in accordance with good practice may be damaged by such accidents, but should be able to stand up without collapsing. As steel is practically an indestructible material, if kept from corrosion, there is no good reason why properly designed steel bridges, properly protected, should not last at least as long as stone bridges in this climate.

About 1886, a new type of iron structure came into existence, viz., the iron skeleton construction for buildings, which has opened a new field for the structural engineer. The designing and construction of the structural part of these buildings has now become an important branch of engineering.

Any engineer who has followed the progress of American bridge building for the last 35 years must have observed that, not only the designs, but also the methods adopted for accomplishing results, have undergone a vast transformation; while, abroad, the designs have been improved, but the methods have changed very little, if at all.

The practice of having the designs of bridges and other structures made by engineers employed by the purchaser, and letting the contract to a manufacturer on a pound-price basis is now becoming the standard practice of the country. Most of the large railroads have their own bridge and structural departments, or, for work of unusual magnitude, employ outside experts to design and supervise construction. Only a few of the smallest railroads adhere to the ancient practice of inviting manufacturers to submit competitive designs accompanied by a lump-sum bid.

The competitive system has had its day and has served a good purpose. It has been an important factor in developing the art of bridge building in America. It has been productive of establishing rational types, practical details and scientific proportions; it has united theory and practice. However, at present, it is fast becoming a thing of the past. What is left of this practice is mostly confined to bridges for electric railways and light structural work. Many purchasers of structural work, who have had no experience themselves, do not seek professional advice, as they would in other cases where large expenditures of money are involved, believing that they can save the money paid for professional services by inviting manufacturers to make competitive designs accompanied by a lump-sum bid.

The fact is, however, that the manufacturer has to pay for making the designs not only once, but many times over, as only once in a number of cases he is the successful bidder. The manufacturer will naturally add this extra expense to the cost of the structure, yet the designs are not made in the interest of the purchaser, but in that of the manufacturer. This practice has a demoralizing influence, as it puts a premium on the poorest design and tends to decrease the professional standard of an important branch of engineering.

The standard practice to be recommended, as the only fair and business-like method, is to let contracts for structural steelwork on a pound-price basis, on designs and specifications furnished by an experienced engineer employed by the purchaser. This method is fair to the honest manufacturer, as all competitors bid on the same basis; it is an advantage to the purchaser, as he employs the engineer who will protect his interests, study the conditions and requirements, and design a structure to suit the needs of his client. It will benefit a number of engineers, who are now compelled to waste their time and energies in making speculative designs to suit the commercial interests of a manufacturer, regardless of good practice, by elevating them to more independent positions, thus enabling them to raise their professional standards to the highest ideals of good practice.

Plans for bridges and other structures, on the safety of which the lives of human beings depend, should be designed and not manufactured; their design and the supervision of their construction should be entrusted only to competent engineers, who, besides the requisite theoretical and practical knowledge, should, above all, be endowed with common sense and good practical judgment.

Most of the largest bridges and other steel structures which have been built in later years have been designed by engineers not connected with manufacturing establishments. The manufacturer should confine himself to his legitimate field of manufacturing structural steelwork at so much a pound. The line between engineers and manufacturers will be even more marked in the future, when the same distinction will prevail as now exists between the architect and the contractor. The manufacturers of structural work, in the future, will devote their energies to improvements in their tools and machinery and methods for handling material. Their engineering force will consist of mechanical experts, shop draftsmen and engineers, who, with a thorough knowledge of shop-practice, are skilled in putting the engineers' designs into convenient shape for the workshop.

Patents on structural designs and details, as well as on special shapes, have become unpopular. Designs of important structures, or those with new features, are

now generally published for the benefit of the profession, and each engineer endeavors to improve upon the design of the other. Beneficial results are derived from papers, submitted to this Society, illustrating and describing new structures, as they bring out valuable discussions and thereby advance engineering knowledge.

Highway Bridges.—Highway bridges in large cities are, at the present time, generally designed by experienced engineers, and the contracts are let in accordance with legitimate practice, the material and workmanship receiving the same careful inspection and supervision as railroad bridges. These structures, however, do not represent the general run of highway bridges throughout the country. In 1852, Squire Whipple stated, in a pamphlet published by him, entitled, "The Canal Bridges, a Specimen of the Manner of Awarding Contracts by the late Canal Board," that the highway bridges over the New York State canals were let to the highest bidders and on the poorest designs submitted. The same conditions exist to some extent at the present day.

These bridges are frequently designed by incompetent or unscrupulous men, and the contracts are awarded by ignorant county officials, without the advice of a competent engineer. The merit of the design receives generally no consideration, and the contract is awarded in many cases to the one offering the poorest design and making a bid which is satisfactory to the officials, if not to the taxpayers. This condition will probably continue until, after repeated disasters, the public demands that competent engineers design and supervise the construction of county highway bridges, and that the contracts be let in accordance with legitimate practice.

Long-Span Bridges.—Long-span bridges have, of late, not only become more numerous, but their length has been gradually increased, until the long-span bridges of former years are now considered spans of moderate size only. The necessity for the great number of long-span bridges in the United States arose from the fact that many wide navigable rivers had to be bridged where the interests of navigation demanded long spans, or where they were required on account of deep and expensive foundations, or on account of other conditions determining the length of spans. There are now in existence in America about fifty railroad bridges containing simple spans of 400 ft. or more, eighteen of which exceed 500 ft., the longest one being the Ohio River Bridge at Louisville, with a span of 546 ft., completed in 1894; there are also a number of highway bridges exceeding 400 ft. span. The length of spans practicable for simple trusses has not yet been reached.

Suspension Bridges.—Suspension bridges were in use in America before any other type of iron bridges. In the earliest suspension bridges, wrought-iron links were used for the cables, and a wooden floor system was suspended from them by iron rods. The first of this kind was built by Finley, in 1796, over Jacob's Creek, on the turnpike between Uniontown and Greensburg, Fayette County, Pa. Many other bridges of the same type were built by Finley after this, the largest one being that over the Schuylkill River, at Philadelphia, Pa., of 306 ft. span built in 1809. The first wire-cable suspension bridge, was also built over the Schuylkill River, at the Falls in Philadelphia, Pa., in 1816; the span was 408 ft. This bridge had a wooden floor system and no stiffening trusses. After this, the wire-cable suspension bridge with auxiliary stiffening trusses became the favorite type for long-span highway bridges, owing to the facility of its erection. Many famous long-span bridges have been constructed of this type, such as: The bridge over the Ohio River, at Wheeling, 1,010 ft. span, built in 1855. The bridge over the Niagara River, at Lewiston, 1,040 ft. span, completed in 1850. The bridge over the Niagara River, carrying the Grand Trunk Railway and the highway, 821 ft. span, completed in 1855. This bridge has become famous as being the only wire-cable suspension bridge carrying highway as well as railroad traffic. The bridge over the Ohio River, at Cincinnati, 1,000 ft. span, completed in 1867. The bridge across the Niagara River, below the Falls, at Clifton, 1,264 ft. span, finished in 1867.

The most notable suspension bridges, however, are the Brooklyn and Williamsburg Bridges, across the East River, New York City. The Brooklyn Bridge, 1,595 ft. span, completed in 1883, was the first bridge of this kind in which steel was used for the cables, suspenders, stiffening trusses and floor system. The Williamsburg Bridge, 1,600 ft. span, completed in 1904, is the latest of the long-span suspension bridges. The proposed Manhattan Bridge, across the East River, New York City, 1,470 ft. span, is also of this type, a novel feature being the hinged steel towers.

Suspension bridges with braced cables in place of auxiliary stiffening trusses, the cables consisting of forged eye-bars, have also been successfully used for long-span bridges. The Point Bridge, over the Monongahela River, at Pittsburg, of 800 ft. span, completed in 1876, is a bridge of this kind. In locations where the appearance of the structure is one of the most important considerations, this type eventually may take the place of the cantilever for long-span railroad bridges.

Metal Arches.—Metal arches are particularly suitable for long spans in certain places. The arch combines the advantages of a graceful appearance with facility of erection without false work. Most of the earlier ones were constructed of cast iron, an important example of which is the Chestnut Street Bridge, in Philadelphia, completed in 1863. The first important steel arch was he St. Louis Bridge, over the Mississippi River, completed in 1874, consisting of three spans, the middle one, of 515 ft., being the largest. The highway bridge across the Mississippi River, at Minneapolis, having two spans of 456 ft. each, was completed in 1888. The Washington Bridge, across the Harlem River, New York City, finished in 1889, consists of two spans, each of 510 ft.

A number of arches of various types followed, the most noted of which are the two across the Niagara River, one of which, of 550 ft. span, carries the tracks of the Grand Trunk Railway and a highway, replacing the Roebling suspension bridge. It was constructed in 1897. The other replaced the Niagara Falls and Clifton Suspension Bridge in 1898. It has a span of 840 ft., and is the largest arch of any type in the world.

Cantilever Bridges.—Cantilever bridges are generally suitable for long spans only; where the length required is too great for a simple truss, or where it becomes necessary to erect without temporary supports, and the conditions are not favorable for an arch. It, perhaps more than any other kind, has been erected in places where simple trusses would have been more appropriate, and freaks of t is kind may be seen in various places.

As the cantilever bridge is not as economical as a simple truss, except for spans of great length, and as simple trusses in many cases can be erected on the cantilever principle, the simple truss is generally preferable to the pure cantilever type. The Atbara Bridge, and the bridge recently erected over the Ohio River on the line of the Baltimore and Ohio Railroad at Benwood, are examples of this kind of construction.

The first cantilever railroad bridge was the Kentucky River Bridge, of three spans, each of 375 ft., completed in 1877, on the line of the Cincinnati & Southern Ry.

Many other cantilever bridges were built thereafter, such as: The Niagara River Cantilever Bridge, on the line of the Michigan Central Railroad, 470 ft. span, completed in 1883. The Frazer River Bridge, on the Canadian Pacific Railway, in 1884, 315 ft. span, and the St. John's River Bridge, in 1885, 477 ft. span. The Poughkeepsie Bridge, across the Hudson River, including a span of 523 ft., finished in 1889. The Colorado River Bridge, at Red Rock, Colo., 660 ft. span, completed in 1890, and the Memphis Bridge, with a span of 790 ft., completed in 1892.

The latest and most conspicuous cantilever bridges constructed are those over the Monongalela River, on the line of the Wabash Railroad, at Pittsburg, 812 ft. span, and at Mingo Junction, 700 ft. span, completed in 1904; also the Thebes Bridge, across the Mississippi, 671 ft. span, completed in 1905. The bridge over the East River at Blackwell's Island, now under construction, has spans of 984 and 1,182 ft., respectively. The longest cantilever bridge is that across the St. Lawrence River, at Quebec, with a span of 1,800 ft., now being built. This will make it the longest bridge in the world.

At the present rate of development of bridge building, with the materials at our command, we may see even longer spans in the near futur. It is entirely feasible to build simple trusses of 800 ft., arches and cantilevers of 2,000 ft., and wire-cable suspension bridges of 3,000 ft. spans.

Monumental Bridges.—Bridges of monumental nature have generally not received the same careful attention in this country as in Europe. There is really not much difference between public buildings and other public works of like importance. While public buildings have been designed for appearance as well as for permanency, public bridges have been notoriously neglected in both respects. Thus in large cities we see many bridges, which are far from being ornamental or sightly in appearance, situated in prominent places and in public parks in the midst of beautiful landscapes.

Such structures, which are in many cases the most prominent objects in a city, should be monumental in character, and designed on aesthetic as well as on engineering principles. Fortunately, in later years, there has been a manifest tendency toward improvement in this direction.

Any experienced bridge engineer is competent to decide upon the proper design of a structure, wherein utility and economy are the only considerations, but not if the structure requires aesthetic treatment, as engineers are generally deficient in aesthetic training. In the design of a structure of monumental character, the engineer should co-operate with a competent architect, who should be a true artist and not merely a decorator. The best results can only be obtained by a competition, such as is the usual practice with other monumental structures, the jury of selection to be composed of engineers and architects. This method was adopted in the selection of designs for the proposed Memorial Bridge and the Red Creek Bridge at Washington, and has proved very satisfactory. The Washington Bridge, in New York City, and the Cambridge Bridge, at Boston (nearly completed), are good examples of monumental city bridges.

Erection.—The erection of structures has kept pace with the rapid progress in structural engineering, requiring the institution of new methods and the development of new appliances demanding engineering sk... The increased weight of members, consequent u... the development of long spans and lofty viaducts... buildings, and the necessity of assembling th... members rapidly and economically, often over treacher... streams, while carrying safely, and without interrupti... e constant traffic of a railroad, have made the ... on one of the most important operations connected w... e construction of the various kinds of engineering... structures,

The introduction of the traveler was a ma... advance in the erection of structures, dispensing with ... tion of the temporary supports. Later, the travel... as developed to erect viaducts and bridges of th... tilever type without the use of any temporary suppo...

Until recent years the question of erection ... left to the skill and judgment of practical men who ... gained their knowledge and had become experts by ... experience. The field operations in connection wi... erection of some of the structures of recent yea... were of such magnitude and complicated character t... it required a high order of engineering skill and ... perience to carry them out to a successful completion. ... direction of bridges and other structures has manifestly ... advanced from being mere skilled labor, executed by me... having only practical training, to be an important b... ch of engineering.

Nickel Steel.—Nickel steel has of late receive... special attention, and has been investigated by engineers, in relation to its usefulness as a structural material. For many years, metallurgists have experimented on the effect of the addition of special metals to steel with a view of increasing the ultimate strength and elastic limit of the steel without proportionately decreasing its ductility. So far, as a special structural steel, nickel steel is the only one which has proved satisfactory.

Nickel steels of varying carbon and nickel have been successfully used during the last fifteen years for marine and stationary engine shafting, locomotive axles, piston rods and crank pins, and a wide variety of forgings and castings for parts of machinery. Its application for the manufacture of armor plate, since 1890, is well known. It has recently been adopted, especially in this country, for gun forgings. It has been proposed for structural work before, but is now actually used for bridge construction in the eye-bars for the Blackwell's Island Cantilever Bridge across the East River, New York City, and may take an important place as a structural material for long-span bridges.

Concrete construction.—Concrete construction has been in use for many years, but is used more extensively now than formerly for foundations, piers and abutments, as well as for bridges. Marked progress was made in concrete construction when the methods of reinforcing concrete with steel were introduced. Concrete arches reinforced with steel ribs or bars, properly designed and constructed, have proved satisfactory for highway as well as railroad bridges, and are gradually superseding those of masonry construction.

Reinforced concrete is now used successfully in the construction of floors of bridges and buildings. It has also proved satisfactory for fireproofing and as a protection, to the steelwork of bridges over railroad tracks, against the corroding influence of the gases from locomotives, and will probably take a permanent place in structural work in the future.

Contracting.—Contracting has undergone a marked development to keep pace with the advances made in bridge building and structural engineering. Deep and difficult foundations for bridge piers and high buildings are more frequently required now than in former years, and while the engineer furnishes the design, it devolves upon the contractor to devise ways and means for doing the work. Many of the problems the contractor has to solve require engineering talent of the highest order, and some of the contractors' engineers are men of exceptional ability and of high standing in the profession.

THE USE OF SUPERHEATED STEAM ON LOCOMOTIVES.*

By H. H. Vaughan, M. Am. Soc. M. E.†

HISTORY.

The use of superheated steam has rather a peculiar history: unlike the turbine, which lay neglected, with its possibilities unknown, through the years in which the reciprocating engine gradually attained its present state of perfection, superheating was employed and proved its value when the steam engine had already left the experimental stage, when reliable operation had become established, and economy was regarded as a matter of importance. After demonstrating the advantages that could be gained by its use, it was gradually abandoned by the large majority of engineers, and not again resorted to until successive stages of increasing pressure, ordinary multiple compounding, jacketing and refined designing, had been brought to their greatest perfection. When its reintroduction took place, its progress was slow, and

*Paper presented at the annual convention of the American Railway Master Mechanics' Association, Manhattan Beach, New York, June 14-16, 1905.

†Superintendent of Motive Power, Canadian Pacific Railway, Montreal, Canada.

ye... were required to obtain its recognition as a neces... in every plant where power is to be obtained with ... greatest economy.

The earliest recorded attempt at superheating as that ... in 1828 by Richard Trevithick, at the Dolcoath Mine in Cornwall, on a condensing pumping engine making eight strokes per minute, with a boiler pressure of 45 lbs., in which the cylinders and steam pipes were surrounded with brickwork and heated from a fire burning on a grate underneath. The results were remarkable, for, while performing the same amount of work, ... lbs. of coal were used per 24 hours without the fire under the cylinder, against 6,000 lbs. when it was in use, the coal for superheating included. This experience led Trevithick to the invention of his tubular boiler and superheater, which was patented in 1832, and was a remarkable modern-looking arrangement, the boiler proper consisting of vertical water tubes surrounding a circular grate and forming a vertical flue in which other tubes were placed, through which the steam, generated in the boiler, passed on its way to the engine. Owing, no doubt, to the difficulty in regulating the temperature of the steam obtained from such an apparatus, little seems to have been done in the matter during the next ten or fifteen years, although in 1832, I. Howard, of Bermondsey, produced a superheater which obtained an economy of 30%, and about 1835, Dr. Haycroft, of Greenwich, advocated superheated steam and found, experimentally, about the same saving.

From 1850 to 1865 the interest in this subject revived considerably, and a moderate degree of superheat was quite extensively employed toward the latter part of that period. Hirn, in 1857, published the results of experiments made by him at Colmar, which were the most carefully conducted tests that had, up to that time, been carried out, and showed that, on a simple engine, working with a boiler pressure of 55 lbs., economies of 20 to 47% could be obtained with superheat of 100° to 190° F. In 1859, John Penn read a paper before the Institution of Mechanical Engineers describing several applications to steamships, the superheater consisting of a number of tubes about 2 ins. diameter placed in the uptake just as it left the boiler, through which the steam passed on its way to the engine. The superheating surface was about 15% of the boiler heating surface, and with a boiler pressure of 20 lbs. on a condensing engine, about 20% saving on fuel was obtained with a superheat of 100° F. John Ryder, in 1860, in a paper before the same society described the Parson & Pilgrim superheater, which consisted of two horseshoe-shaped pipes placed in the internal flue of the boiler over the fire grate, and the Partridge, which was a cylinder filled with tubes through which the gases passed, the steam being around them. Both of these systems were stated to have given good results, which may appear rather questionable in the case of the former, but a total of 5,000 HP. had then been equipped. The superheating surface employed was 2½ to 2¾ sq. ft. per nominal horse-power, or about the same as that described by Penn, and the economies obtained were practically equal.

Sundry other systems were in more or less extensive use about this time, such as the Crossland, Wethered, etc., and extensive experiments were carried out by Isherwood, in the American Navy, which confirmed the good results obtained abroad.

While a large amount of evidence was thus created in favor of superheating, and it was employed to a considerable extent, placing it beyond the experimental stage, it gradually gave way before the development of increased boiler pressure and compounding, which commenced about 1865. When boiler pressures were from 20 to 40 lbs., superheaters in the uptakes, which gave 100° to 125° of superheat, could be employed without exceeding a temperature in the cylinder at which the animal lubricants used in those days would decompose and attack the valve faces and cylinder bores, but as the pressure was increased, the same amount of superheat could not be used. The absence of moisture in the superheated steam made lubrication necessary, and the packings used on valve stems and piston rods were also badly adapted for steam at high temperatures and gave considerable trouble when 350° was exceeded. Trouble was also experienced in the superheater tubes, caused by deposits of salt on account of the use of the jet condenser, which was then universal. By employing a higher boiler pressure and avoiding cylinder loss by compounding, the same economy could be obtained as by superheating with a decrease in trouble, and its use gradually declined until about 1870 it was rarely employed on new work, excepting by the Alsatian group of engineers, by whom it was never abandoned. With the introduction of hydrocarbon lubricating oils, balanced valves and improved packing, the use of considerably higher temperatures became possible, and in 1890, interest in this subject was renewed by the attention drawn to the results being accomplished in Germany by such engineers as Gehre, Schwoerer, Uhler and others. Many results were published, all of which showed a gain from the practice, and in England, in addition to the introduction of their apparatus, several other types were developed along similar lines. Since that date the progress of superheating in stationary practice has been comparatively steady, although slow, and it has in general developed along the lines of moderate superheat, say from 50° to 100°, no special type of engine or boiler being usually employed, and its subsequent history, with one notable exception, concerns stationary and marine practice rather than locomotive. That exception is the use of highly superheated steam, perfected after 14 years' experimenting by Mr. Wilhelm Schmidt, of Cassel, who succeeded about 1894 in producing a boiler and motor in which steam, superheated to 700°, was used at comparatively low pressures. The results obtained were reported by Messrs. Schneider and De Grahl in 1894, and were exceedingly economical, especially on small engines, and in 1898, 200 plants were reported to be working on the Schmidt system; but apart from these, highly superheated steam can hardly be said to have come into general use. In view of the present applications of superheated steam to locomotives, the general lines of its introduction into stationary and marine practice are interesting. Moderate superheating, employing temperatures up to 150° above that of evaporation, first scientifically investigated by Hirn, introduced extensively into early English marine practice by Penn and others and then abandoned; continued in stationary practice in Alsace by Hirn's pupils and followers, has, in the last ten or fifteen years, become extensively used in stationary practice with increasing steam pressures. High superheating, developed by Schmidt, has been economical and satisfactory where employed, but so far, is not in general use.

Superheated steam is supposed to have been first applied to locomotives on the Chicago, Burlington & Quincy Railway in 1870, the front tube sheet being set back some distance into the boiler, and the superheater, consisting of a separate cylinder in which the tubes formed practically a continuation of the boiler tubes and into which the steam entered by the dry pipe, and from it passed to the cylinders by pipes connected to the bottom. Such an apparatus could not have actually superheated the steam to any great extent, but it showed some economy which was not, however, considered sufficient to pay for its increase in cost and the trouble of maintaining it, and it was subsequently abandoned. The present development in the application of superheated steam to locomotives is due to Messrs. Garbe and Muller, of the Prussian State Railways, who in 1898, arranged to equip two engines, Hanover No. 74, built by the Vulcan Company, of Stettin, and Cassel No. 131, built by Henschel & Co., the design being prepared by Mr. Schmidt. In a paper read by Mr. Garbe in 1902, before the Berlin branch of the Institution of German Engineers, he related the various reasons that led him to a consideration of the advantages of superheated steam, and discussed in a comprehensive way the benefits derived from its use and the results at that time obtained. This paper is of special interest, as it describes the first modern application of superheated steam to a locomotive, and shows it to have been a decided success. These engines were followed by others, for which Mr. Schmidt designed what is now known as his smoke-box type of superheater, and in 1899 one engine was put into service with this device. It was followed in 1900 by three others, and in 1902 by 24, 13 of the latter being eight-coupled freight engines, until by the end of 1904 the Prussian State Railways had put into service 127 engines using superheated steam, all except the original two and the last one having the smoke-box type of superheater. Other European roads have, since 1902, also built engines with the Schmidt designs of superheaters, the smoke-box and smoke-tube types being used about equally and in all about 170 of these engines are in service. Other engines have also been equipped with the Pielock, a rather different type of superheater to the Schmidt, which was developed in 1902, and which has now been applied to about 30 locomotives, 13 of these being on the Prussian State Railways, so that, in all, fully 200 engines in Germany are now running with superheated steam. In America it was introduced by Mr. Roger Atkinson, then mechanical superintendent of the Canadian Pacific Railway, who, in 1901, applied a Schmidt smoke-box superheater to an 18 × 24-in. ten-wheel simple freight engine with 62-in. wheels. This engine proved exceedingly satisfactory, and was followed two years later by two ten-wheel compound freight engines, which were equipped with the Schmidt smoke-tube arrangement. All these engines showed a substantial economy over similar engines of the ordinary type, and, in 1904, 41 simple consolidation engines were built, of which 20 were equipped with the Schmidt and 21 with the Schenectady superheater. During that year one of the latter type was also applied to an Atlantic type simple engine on the New York Central and to a ten-wheel passenger engine on the Canadian Pacific. During the present year, 1905, the Canadian Pacific Railway is building 55 simple ten-wheel freight engines and six Pacific type passenger engines, which will be equipped partly with the Schmidt and partly with modified Schenectady and other types of smoke-tube superheaters, and a number of other roads are also experimenting with this system, which is therefore fairly well started, experimentally, and is now in sufficiently extensive use to develop its troubles in regular service, and emerge from the nursing stage, which always engenders the suspicion that particular attention to one engine's performance may obtain results that would not be realized from a number.

DESIGNS.

The designs of superheaters so far used are chiefly due to Mr. Wilhelm Schmidt, who has devolped two distinct arrangements, both of which are of that type in which a portion of the number of flues is utilized for superheating. The design most generally used abroad, which is known as the Schmidt smoke-box superheater, is illustrated in Fig. 1, and its special feature consists in the use of a tube of large diameter leading from the fire-box to the front tube sheet, by which a considerable portion of the flue gases are delivered at a high temperature into an annular chamber at the front end, within which the superheater tubes are placed. The steam from the dry pipe passes into the rear end of a header, placed near the top of the smoke-box on the right side, which header is divided into a front and back portion by a transverse partition. From the back of the header the steam passes through the small superheater pipes to the rear end of a corresponding header on the left side, and from the front of that header through other superheater pipes to the front section of the right-hand header, and thence to the cylinders. The superheater pipes are curved to surround the gases flowing from the large tube, which then pass upward on each side and then into the smoke-box proper. As in all superheaters of this type, a damper is provided to close off the flow of gases through the superheater when the engine is shut off, as at that time there is no steam in the superheater pipes, and they would be damaged by the hot gases if they were allowed to pass through freely. While this type of superheater has been extensively used in Germany, it has only been applied to one engine in America (No. 548 on the Canadian Pacific Railway), and although the results obtained from it have been exceedingly satisfactory, and any desired amount of superheat can be obtained by an adjustment of the amount of gas passing through the large tube, it is doubtful whether it will actually make very much headway in this country. There is considerable complication in the front end, and a number of steam-pipe joints, which, while they have not given any trouble so far, are certainly objectionable, and since in the other design of superheater developed by Mr. Schmidt these difficulties are overcome, it appears probable that the latter, which is known as the smoke-tube superheater, will be the one generally employed. This design is shown in Fig. 2 and a later modification of it in Fig. 3, from which it will be seen that in the upper portion of the tube sheet, a number of large tubes—in this case 21—are used in place of the ordinary 2-in. or 2¼-in. tubes. These large tubes are 5 ins. diameter, reduced to 4 ins. at the back tube sheet, and each contains two loops of 1¼-in. superheater pipes connected at the back end by steel return bends. The steam passes from the dry pipe to a transverse header in the smoke-box, which is divided by partitions into two portions, one for saturated and the other for superheated steam, and is arranged with a face on its lower side, having openings communicating with the saturated and superheated steam compartments. The loops of superheater pipes are expanded into flanges which are secured to this face, and the steam passes from the saturated steam compartment through the superheater pipes to the superheater steam compartment in the header and thence to the cylinders. In the modification shown in Fig. 9, the face on the header is in the front in place of underneath, and the superheater pipes, in place of being formed in single loops, are in double loops, thus doubling the rate of flow of the steam through them and also the heating surface per loop. The amount of superheat obtained in this design depends upon the number of loops of superheater pipe, and Mr. Schmidt has recommended that, in place of 22 large tubes and 248 2-in. tubes, as shown in these illustrations, which took the place of 378 tubes in a similar boiler without the superheater, that the number of large tubes should be increased to 30 and the 2-in. tubes reduced to about 190. He also advises that the double loop arrangement gives superior results to the single and obtains a higher degree of superheat, both of which statements appear very probable.

In both of these arrangements, any required element of superheater pipes can be got at without disturbing all the others, but as originally designed, the flanges were secured by a clip bearing on two adjacent flanges with a bolt between them, and while this arrangement, once tight, gave no trouble in service, it is exceedingly difficult to get it tight to commence with, and it is now being superseded on the Canadian Pacific Railway by independent bolting to each flange. The arrangement shown in Fig. 3 has not been so far used in America, and is chiefly interesting on account of the double looping, as it would not work in quite as well as the earlier arrangment on an American engine. This general design of smoke-tube superheater is a good mechanical arrangement, and has so far been very successful. With the proportions illustrated, the same amount of superheat can not be obtained as with the smoke-box design, but it has developed no faults and it is difficult to see what expense will be incurred for maintenance. It can be applied very conveniently to the ordinary design of locomotive, simply requiring the front flue sheet to be set back

slightly further than usual, but without further change, and on account of its simplicity will probably be extensively used in the future.

The Schenectady superheater is a modification of the Schmidt smoke-tube type and differs from it chiefly in the arrangement of the headers, and also in the usual use of an inner and outer pipe for leading the steam to the rear end of the superheater tubes in place of the looped pipes. The original form is illustrated in Figs. 4 and 5, Fig. 4 showing the arrangement of the headers and Fig. 5 the method of closing the outer end of the superheater pipes. In place of the superheater pipe in each superheater tube being expanded into flanges, which are bolted to the header, the pipes forming one vertical row of superheater tubes are all expanded into a sectional header, which is itself divided into saturated and superheated steam compartments. These sectional headers are in turn bolted to the main header, openings being arranged to correspond in the two compartments. This arrangement is very simple and convenient, and as each sectional header can be removed without disturbing others, it is convenient for repairs. The inner and outer tube arrangement reduces the number of joints considerably, through which steam may probably leak into the front end, but so far it can not be definitely stated that this arrangement is as efficient as the looped pipe. There is no reason, however, why the sectional headers can not be used in connection with the looped pipe, and on 30 engines now being built for the Canadian Pacific Railway the arrangement of looped pipes is identical with that used in the Schmidt smoke-tube superheater, but the pipes are connected to sectional headers of the Schenectady type as shown in Fig. 6. Fig. 5 shows the arrangement of inner and outer superheater pipes and also the latest method of joining the plug at the end, which is supported with a small bracket in the tube. The original engines turned out with this design had 3-in. superheater tubes in which were placed pipes 1¼-in. diameter, with an inside pipe 1-in. diameter. These engines gave considerable trouble from the tubes stopping up with cinders, and a more recent design is shown in Fig. 7, in which 5-in. tubes are used as in the Schmidt arrangement, but in place of loops, four Field tubes are placed in each 5-in. tube. One point of this arrangement is worthy of note, namely, the disposition of the pipes to allow a rod being passed through between them for cleaning purposes; ease of cleaning is quite an important factor in superheaters, as in any design there is a liability of the tubes being stopped up by cinders, and while the looped pipe types do not give any serious trouble in this respect, the 3-in. tubes with single pipe inside have proved difficult to clean. The bending of the pipes to the header in the Schmidt arrangement is especially designed to permit of easy cleaning, as in Germany and other European countries it is the practice to clean the flues from the front end in place of from the fire-box, as in America. No trouble has been experienced in keeping the superheater pipe joints tight in the Schenectady arrangement and the joints between the sectional and main headers are easy to make and remain tight in service, so that it may be safely stated that this design is good mechanically and suitable for American conditions, although further evidence is needed to decide whether the Field tubes are as efficient as the looped pipes.

The superheaters so far described are all of the type in which a portion of the number of the tubes is devoted to superheating, and as yet there is only one superheater in use of the second type, in which a portion of the length of the flues is used for that purpose. This superheater, called the Pielock, is illustrated in Fig. 8, and it will be seen that the flues pass through a superheater about the center of the boiler, through which the steam passes on its way to the throttle. The steam enters the superheater through a vertical pipe extending up into the dome, so as to obtain it in as dry a condition as possible, and is traversed across the flues by vertical partitions in the superheater, thus being in contact with them for a considerable distance before passing to the throttle. Since the superheater is always filled with steam at boiler pressure there is practically no tendency to leakage, and as, in addition, the temperature of the flue gases is lowered by contact with the flues before reaching the superheater, no damper arrangement is required. The tubes are slightly enlarged where they pass through the tube sheets of the superheater and are expanded at those points in order to make water-tight joints, and in case of any leakage or condensation occurring while the engine is at rest, a drain cock is applied to the superheater chamber. This superheater has several advantageous features from the theoretical point of view; any desired amount of superheat can be obtained by varying the distance it is placed from the back tube sheet and the length of the superheater, no damper arrangements are required, the efficiency of the boiler is but little affected by the addition of the superheater, and the ordinary size of flue is alone used, so that no special regulation of the draft is required. On the other hand, there are certain practical difficulties that may be experienced in its use, such as the possible loosening of tubes in the superheater tube sheets, which may lead to leakage that is not readily detected; increased trouble from flue leakage in the back tube sheet due to the movement of the flues being prevented by their attachment to the superheater, which may necessitate their moving in the flue sheet as their relative temperature varies, and trouble in removing incrusted flues through the holes in the superheater sheets. It can not be stated that any of these objections have been developed in service, but they appear probable, and while the Pielock superheater would appear to be, in certain respects, the most satisfactory so far designed, yet it must demonstrate its freedom from practical objections before it can be generally used. No superheater other than those described has so far been used to any extent on locomotives, but it is probable, in the future, that both modifications of the arrangements illustrated and other designs will be brought out, and a reference to the patent records will show a number of superheaters of more or less promise, which have not so far come into practical use and need not therefore be referred to for the present.

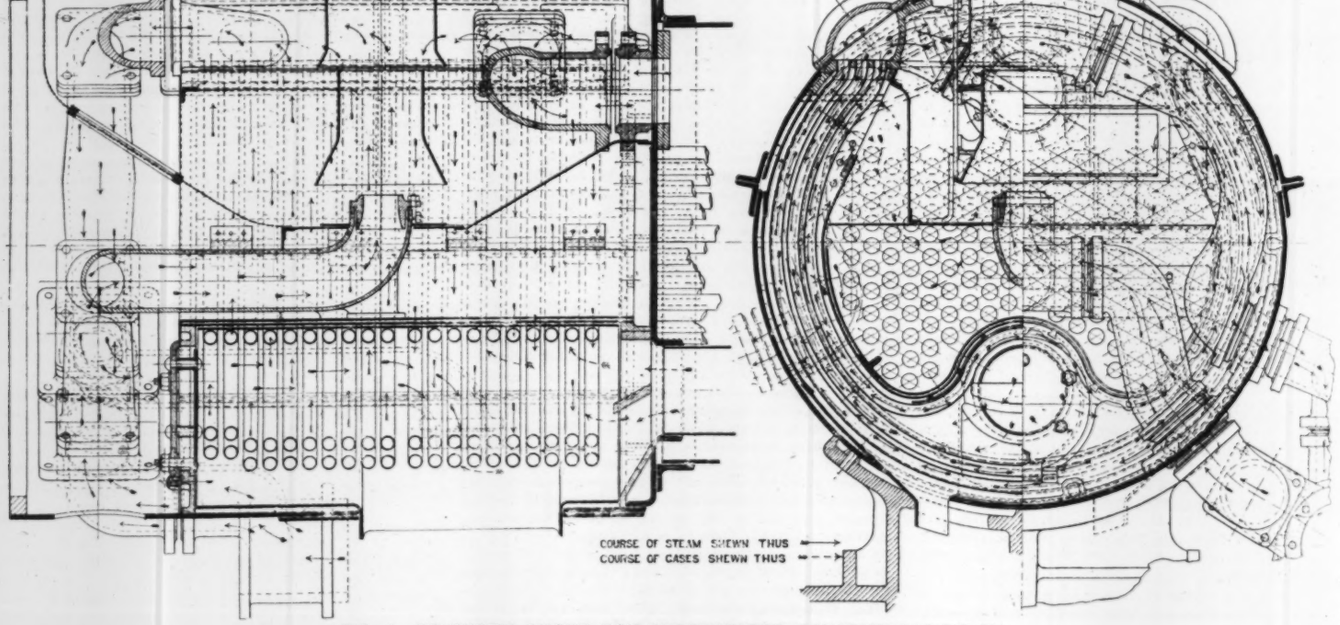


FIG. 1. SCHMIDT'S SMOKE BOX SUPERHEATER, CANADIAN PACIFIC RY.

RESULTS.

The results obtained from superheating appear bly to have shown a decided economy. Starting instance previously referred to as reported by Tr in which an economy of 30% was obtained with known degree of superheat, but in which 7% total coal burned was used in the superheater, a various tests show a remarkable agreement in A short statement of a number of experiment follows, is interesting as showing a general a among a number of investigators:

Hirn, in a report issued in 1857, describing th of various experiments carried out by himself on engine working at a pressure of 55 lbs., obtain mies of from 20 to 45% with steam superheated 410° to 490° F.

John Penn, before the Institute of Mechanica neers in 1859, reports on a condensing marine en the S. S. "Valetta," 200 HP., boiler pressure boiler heating surface 4,950 sq. ft., superheat 4 tubes in smoke-box, superheating surface 720 superheat 100° F. Saving, 20% in fuel.

John Ryder, in a paper before the Institute of M ical Engineers, 1860, reports on a condensing mari gine on the S. S. "Buster," boiler pressure 10 lbs., heater two return-pipe over fire, superheat 144°. 25% in fuel.

Bryan Donkin, article in "Engineering," 1891, on a simple non-condensing horizontal engine. Boiler pressure 50 lbs., revolutions 220, superheat 50° F. Saving, 15 to 27%, dependent on cut-off (probably water consumption). Higher temperature of cylinder walls noted.

W. H. Patchell, paper before Institute of Mechanical Engineers in 1896, reports on a horizontal tandem compound condensing engine, 300 HP., cylinders 18 ins. and 36 × 48 ins. Boiler pressure 100 lbs.; superheater, Hick, Hargreaves & Co., superheat 42° to 55°. Economy in water, 9.6%.; in coal, 19% (indicates part gain due to more efficient boiler results, water evaporated per pound coal, increase 13%).

Other tests on Lancashire boilers show a very similar result, considerable gain being shown in water evaporated per pound of coal.

There are any number of similar instances in stationary practice, and it is significant that such decided gains have invariably been obtained from simple non-condensing engines, and this fact would lead to the expectation of decided benefits in locomotive work.

The tests of the first locomotive equipped, Hanover No. 74, which were reported by Mr. Garbe, in his paper of 1902, showed excellent results in comparison with two similar, but compound locomotives Nos. 73 and 49. On a nine days' test from October 16 to 25, 1901, running passenger trains averaging 35 axles and 360 tons from Grunewald to Saumerfauld and back (104 miles), the superheated locomotive consumed per train mile 34.2 lbs. of coal and 206 lbs. of water, with an evaporation of 6.05 lbs. of water per pound of coal. The compound locomotives consumed 37.8 and 38.2 lbs. of coal, respectively, and 279 lbs. of water per train mile, the evaporation in

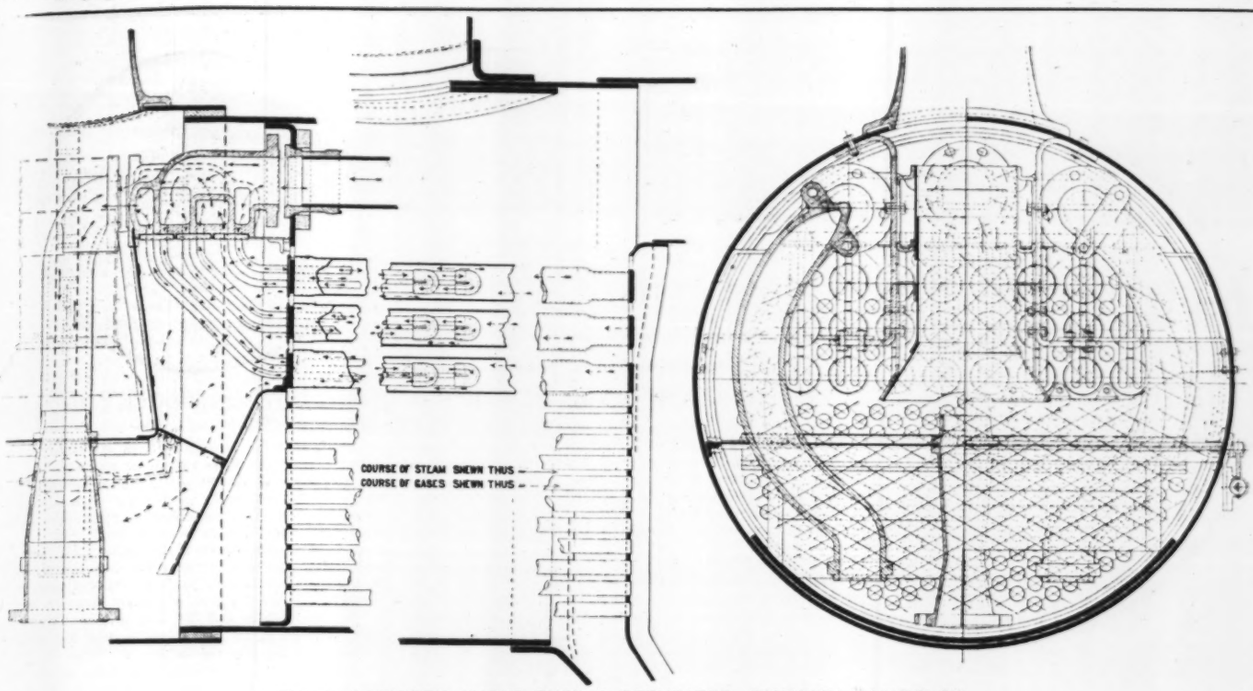


FIG. 2. SCHMIDT'S SMOKE TUBE SUPERHEATER, CANADIAN PACIFIC RY.

their case being 7.37 and 7.30 lbs. of water per pound of coal. The compound locomotives therefore required 11½% more coal and 30% more water than the superheater, but the boiler of the latter was evidently less efficient, as an evaporation of 7.35 lbs. saturated steam would equal 6.60 lbs. superheated 200°. Other tests with locomotives 2063 and 2070 showed equally good results, a saving of about 15% in coal being obtained with a steam temperature of about 520°. A large number of indicator diagrams from these tests are shown in Mr. Garbe's paper, and they are exceedingly satisfactory.

In 1901, trials were made by Mr. Von Borries on the Royal Hanover Railway, between a four-cylinder compound, No. 11, a two-cylinder compound, No. 38, and the first engine fitted with the smoke-box superheater, No. 86. These engines were all 2-4-0 passenger engines with driving wheels 78-in. diameter, No. 11 having 13-in. and 20½-in. cylinders, No. 38, 18.1-in. and 26.8-in. cylinders, and No. 86, 18.9-in. The length of run from Hanover to Stendel was 93½ miles. In these tests the consumption of coal and water and evaporation was as shown in Table I.

The superheater engine, while showing a saving of 10 to 15% in water as compared with the compounds, showed a loss of 2 to 4½% in coal, but this test has occasioned a large amount of controversy in Germany, and Mr. Garbe has pointed out that on the run on which these trials were made, the trains were lighter and the line less severe than in the case of the trials of engine No. 74, yet the coal and water consumption in the case of engine No. 86 was considerably greater than that of No. 74. Any one desiring a critical analysis of these tests can be gratified by referring to the Bulletin of the International Railway Congress for February, 1904, in which translated papers by Mr. Teuscher and Otto Berner were published.

In 1902 Mr. Von Borries made further trials between two new four-cylinder compounds, Nos. 17 and 18, two new superheated simples of the Schmidt smoke-box type; Nos. 439 and 440, and one two-cylinder compound, No. 42 The grate area of all these engines was the same, 24.43 sq. ft., and the heating surface of the three types 1,277, 1,134 and 1,345 sq. ft., respectively. The boiler pressure of Nos. 17 and 18 was 210 lbs. and that of the others was 180 lbs. A large number of runs were made between Stendel and Hanover, the mean speed over a distance of about 75 miles averaging 54 to 56 miles per hour. The drawbar pull for the train was calculated by the formula:

$$T = W\,(0.8 + V\,\frac{V+80}{17{,}300})$$

that of the locomotive by:

$$T = W\,(1.9 + V\,\frac{V+48}{5{,}760})$$

where T is tractive force in pounds, W weight in tons (2,000 lbs.), and V, speed in miles per hour. The average temperature of the superheated steam in Nos. 439 and 440 was 527°, and the averages of the more important results were as shown in Table II.

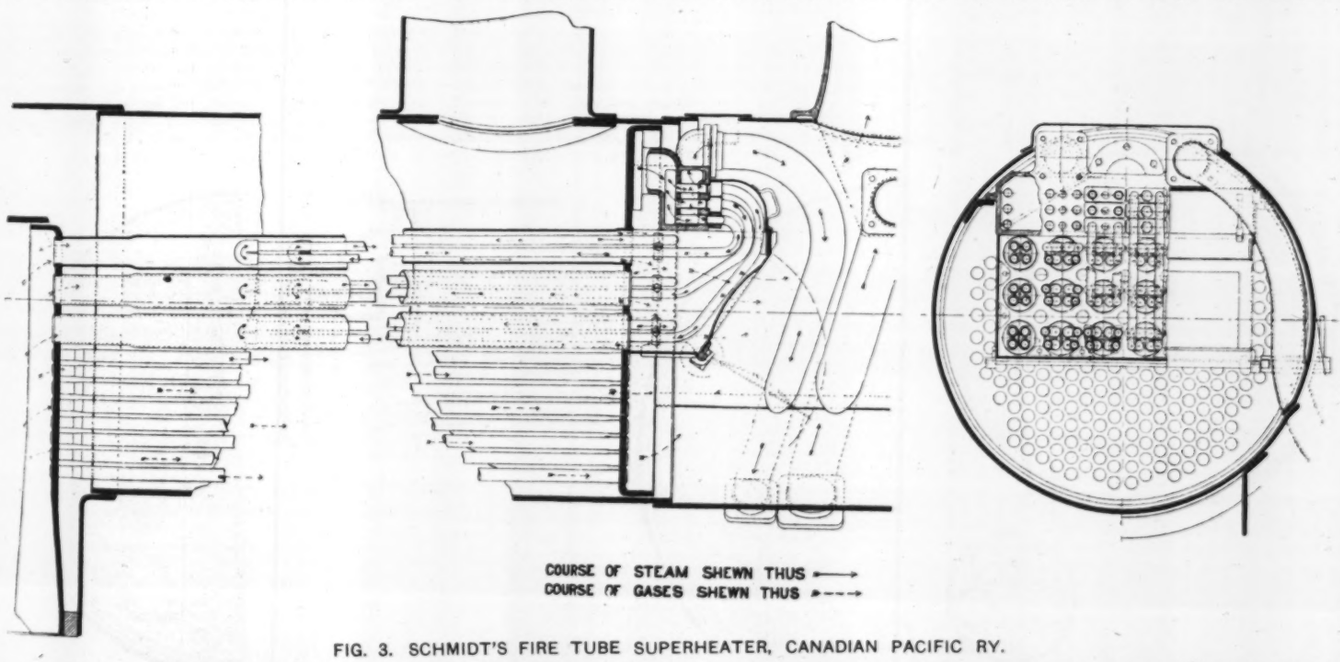


FIG. 3. SCHMIDT'S FIRE TUBE SUPERHEATER, CANADIAN PACIFIC RY.

Table I.—Test on the Royal Hanover Ry., 1901.

Engine.	Coal per mile.	Water per mile.	Water per lb. coal.	Relative consumpt'n. Coal.	Water.
No. 11 4-cyl. compound .	38.8	280	7.27	98.0	110
No. 38 2-cyl. compound .	37.8	294	7.78	95.5	115
No. 86 superheater.	39.6	255	6.44	100.	100

In this test the superheater simple obtained results practically equal to the four-cylinder compound and superior to those of the two-cylinder. It was also worked rather harder, the average speed of the runs made by it being 2.9% greater than those made by Nos. 17 and 18. The boiler performance is again inferior to the engines without superheater, although better than that usually obtained in America, but as the superheat was about 150°,

Table II.—Tests on the Royal Hanover Ry., 1902.

Description.	Nos 17 and 18.	Nos. 439 and 440 (superheated).	No. 42
Number of runs	20	22	12
Duration of run, minutes.	112.3	108.5	114.7
Net time of trip, minutes.	107.3	103.5	109.7
Mean speed for 75 miles..	54.8	56.4	54
Weight of train, tons.....	315	302	284
Water per round trip, lbs..	51,160	45,780	50,100
Coal, per round trip, lbs..	6,662	7,030	6,472
Water, per mile, lbs.....	35.7	37.6	34.6
Coal per mile, lbs.....	274	245	268
Water evaporation by coal	7.67	6.54	7.78
Relative evaporation	117	100	119
Coal per HP. hour, total lbs.	2.08	2.17	2.32
Relative consumption	96	100	107
Coal per HP. hour at drawbar, lbs.	3.65	3.76	4.46
Coal per square foot grate per hour, lbs.	76.3	83.3	73.2

had the boiler efficiency been the same as on Nos. 17 and 18, the evaporation would have been 7.1 lbs. of water per pound of coal and in place of the four-cylinder compound showing a gain in coal per total horse-power hour of 4%, it would have shown a loss of 3%. As a confirmation of this test, Mr. Von Borries states that the consumption of coal per mile for the same engine in regular passenger service, was, during six weeks, 39.42, 40.16 and 39.81 lbs. per mile for these types respectively, figures which agree fairly well with those obtained on trial. In some similar trials on the Halle Railway between the same class of four-cylinder compounds and simple superheaters, the results were as follows:

Description.	Four-cylinder compound.	Simple superheater.
Coal, pounds per mile.....	38.9	37.9
Relative consumption	103	100
Water, pounds per mile	270.2	226.5
Relative consumption	119	100
Evaporation	6.96	5.98
Relative evaporation	116.5	100.

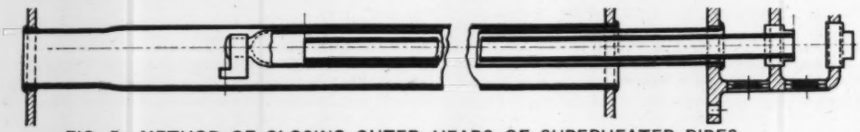


FIG. 5. METHOD OF CLOSING OUTER HEADS OF SUPERHEATER PIPES, SCHENECTADY SUPERHEATER.

In this test, the superheater engine has a slight advantage in coal consumption, but there is the same large difference between the water and coal figures, showing a decreased boiler efficiency in the superheater. Some 0-8-0 freight engines were also tested on the Royal Saarbrucken Railway, the superheater engines being simple and weighing 122,000 lbs., the two-cylinder compounds weighing 117,000 lbs., the train loads being practically proportional. The results were stated per 1,000 miles per axle and were as follows:

Description.	Compound.	Superheater.
Coal burner, pounds	605.6	567.3
Relative performance.....	107	100
Water used, pounds	4,459	4,070
Relative consumption	110	100
Evaporation	7.38	7.18
Relative evaporation	103	100

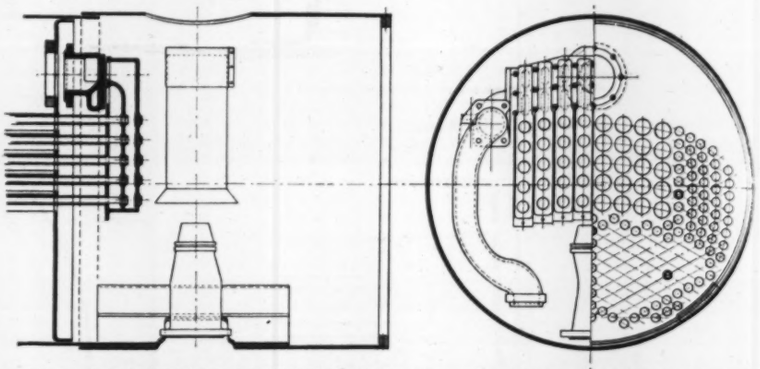


FIG. 4. ARRANGEMENT OF HEADERS IN SCHENECTADY SUPERHEATER, CANADIAN PACIFIC RY.

a temperature. These tests have been presented at some length to show the possibility of a substantial economy in water being neutralized by a loss in boiler efficiency, and by this is not meant the decrease in the evaporation due to the additional amount of heat in the steam delivered to the engine, but a further decrease, which can only be due to one of two causes, the gases that pass through the superheater leaving it at too high a temperature or the reduction in the number of flues used for evaporative purposes increasing the velocity of the gases in those flues so that their temperature, when leaving, is too high. The latter reason does not appear possible and the Schmidt smoke-box superheater is certainly very liable to lead to the first, although it can be avoided by proper adjustment, and it appears probable that the poor boiler results in these trials may be accounted for in this way. It should be noted, therefore, that the superheater simples showed an economy in water of 14 to 15% over a four-cylinder balanced compound in passenger service which, allowing an average of 150% of superheat, would permit of an economy in coal of about 7%, and that the average coal consumption in passenger service is actually the same, and in freight service better than the compound engine. An extensive test was carried out by Mr. Strahl, of the Breslau District of the Prussian State Railways, between two 2-4-0 passenger locomotives, No. 9 simple and No. 54 compound, equipped with the Pielock superheater, and two similar engines, No. 4 simple and No. 60 compound, using saturated steam. The results are given in Table III.

the result that the locomotive with the superheater used almost exactly the same volume of steam as the locomotive without and Mr. Strahl has also advised that this approximation hold very closely for other engines using superheated steam. He states that for several months some 0-8-0 engines with Schmidt smoke-box superheater have been compared with the same class without the superheater and that the resulting economy in water has been 25.3% and in coal 15.25%. On the basis of equal volumes with the degree of superheat obtained, the figures would have been 24 and 17% respectively. An interesting result arrived at by Mr. Strahl is that flat slide valves worked satisfactorily up to 520° F. The German trials described above are remarkably uniform in one respect—the considerable water economy effected by superheating, and they also show that while a falling-off in boiler efficiency must be guarded against, it need not occur, at any rate, beyond 2 to 5%. In the tests made by Mr. Von Borries, it must be remembered that the engine with which the superheater simple was compared is the most efficient type of compound, that the water economy shown in comparison with it is a high recommendation for the superheater, and in view of the probable improvements in boiler performance, it will, no doubt, in the future, be possible to show a corresponding economy in fuel.

Turning from the results obtained abroad to those in America, the only figures so far available are those on the Canadian Pacific Ry. and on this road the records available are those obtained in service over a considerable period. These results, after all, must be deciding ones, as in view of the influence of the boiler efficiency on the net economy, isolated tests will always be more or less unsatisfactory. It is possible to determine the water consumed per unit of power developed with considerable accuracy, but in determining the water evaporated per pound of coal, a factor must be taken into account that is independent of the boiler, and pretty near everything else on the road, in the efficiency of the fireman. It is quite possible, on a test, to obtain an evaporation that it decidedly better than that realized day after day in service, and while no doubt careful tests are desirable, and it is the intention to carry them out as soon as a dynamometer car is available for the purpose, yet the service results are so far satisfactory and are interesting as showing the economy actually obtained.

The records from engine No. 548 extend over a period of 17 months, during which time this engine was com-

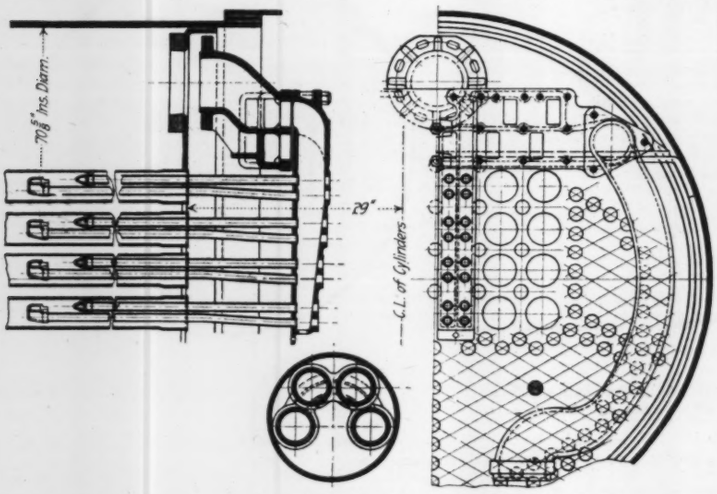


FIG. 6. PROPOSED SCHENECTADY SUPERHEATER ARRANGEMENT, WITH 3-IN. TUBES.

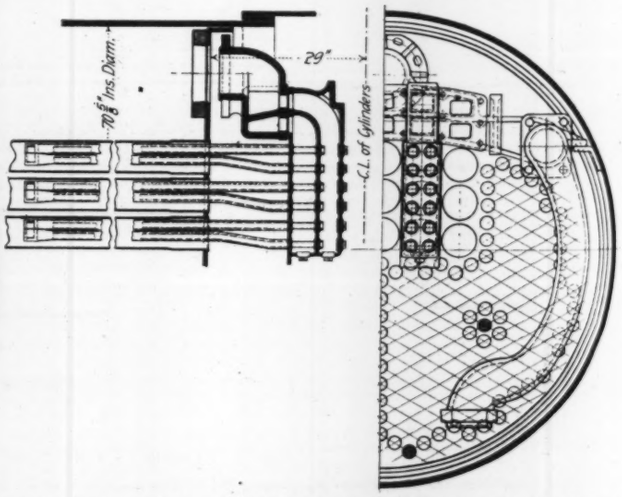


FIG. 7. PROPOSED SCHENECTADY SUPERHEATER ARRANGEMENT, WITH 5-IN. TUBES.

It will be noticed that the boiler performance of the superheater in this case is decidedly better and that while the economy in water is not as great as in previous trials, yet the coal economy is better. This may be due to the engine not having been worked as hard as in the previous trials, and consequently those gases passing through the superheater would not leave it at so high a temperature or the reduction in the number of flues used for evaporative purposes increasing the velocity of the gases in those flues so that their temperature, when leaving, is too high. The latter reason does not appear possible and the Schmidt smoke-box superheater is certainly very liable to lead to the first, although it can be

In these tests the saving in water was accompanied by a corresponding saving in fuel, although in the compound superheater the boiler performance drops off a little, although the superheat is low and, in fact, the superheat in these trials was only moderate and not as high as that advocated by Schmidt. In an article written by Mr. Strahl giving the results of his experiments he arrives at

TABLE III.—Tests on the Prussian State Railways.

Description.	No. 4	No. 9 (superheater).	No. 60.	No. 54 (superheater).
[illegible]meter of cylinder	16½	16½	18½ and 26½	18½ and 26½
[illegible]	23⅝	23⅝	23⅝	23⅝
[illegible]meter of drivers	78″	78″	78″	78″
[illegible]ng surface, square feet	1,349	1,123	1,270	1,044
[illegible]heater surface, square feet	226	226	226	226
[illegible]area	24.43	24.43	24.76	24.76
[illegible]ge weight of train, including engine and tender	283	283	309	309
[illegible]tance run, miles	1,193	1,193	2,360	2,360
[illegible]king pressure, pounds	170	170	170	170
[illegible]perature of superheated steam in dome	500	500	446	446
[illegible]perature of feed water	50°	50°	50°	50°
[illegible]age consumption of steam per hour, pounds	9,508	8,069	11,618	10,459
[illegible]age consumption of coal per hour, pounds	1,195	1,047	1,574	1,519
[illegible]nomy of water, per cent	16	16	10	10
[illegible]nomy of coal, per cent	12.3	12.3	3.5	3.5
[illegible]r evaporation per pound coal	8	7.70	7.70	6.88

[illegible]d with similar simple and Vauclain compounds in [illegible]ght service and with simple and two-cylinder Pitts[illegible]g compounds in passenger service. The dimensions of [illegible]e various engines are given in Table IV.

These engines were compared for periods in which they were running in corresponding service to No. 548 between Montreal and Smith Falls, a practically level division with rolling grades with a maximum of 0.5%, and the results are given in Table IVa. The column marked "Relative Economy," in each case showing the amount of coal consumed by engine No. 548, as compared to the engine with which it was tested.

Noting that Nos. 616 and 634 are simple engines and Nos. 595 and 482 are compounds, these results show satisfactory agreements and would show that this engine consumed about 75% of the coal required by a simple engine and 82% of that required by a compound in similar service. The superheat obtained in this engine is, however, high, running from 550° to 650° according to conditions, and it may be considered as representing the extreme limit to which superheating can be conveniently carried. There is no doubt that the results that have been obtained are exceptionally economical and the engine has been a favorite with the men handling it in any service. The valve and cylinder arrangements of this engine were designed by Mr. Schmidt and have given entire satisfaction at the temperature mentioned above, although when the superheat was raised above 700° a certain amount of trouble was experienced with the lubrication and packings.

The results from engines 1,000 and 1,300 extend over a period of nine and eleven months respectively, during which time these engines were compared with engines identical in every respect except that of not being equipped with a superheater. The dimensions of these engines are given in Table V.

Engine 1,000 was compared with Nos. 996 and 997 for periods in which they were running in corresponding service between Montreal and Smith Falls in freight service. Engine 1,300 was compared with No. 1,319 in corresponding service between Chalk River and North Bay, and North Bay and Cartier; these divisions are very similar, Chalk River to North Bay being an undulating road with several grades four to seven miles long with occasional stretches of 1%, but more generally 0.6 to 0.8%, the total rise on the division being 135 ft. From North Bay to Cartier, the road is undulating except for one rise of 480 ft. in 16 miles, the limiting grades being 1% and the total rise 230 ft. The results are given in Table Va. arranged as for engine No. 548.

These results are rather more favorable to the superheater engines than would have been expected, especially in the case of engine 1000, where it will be seen that this engine gave considerably better comparative results than No. 1300. These engines also being equipped with the smoke-tube type of superheater did not obtain the same degree of superheat as No. 548, generally running from 500° to 550°. There was a certain amount of leakage from the boiler of 1000, 996 and 997 class during the period, which makes the comparison of less value than those for 548 and 1300, but in spite of this, the results are evidently satisfactory.

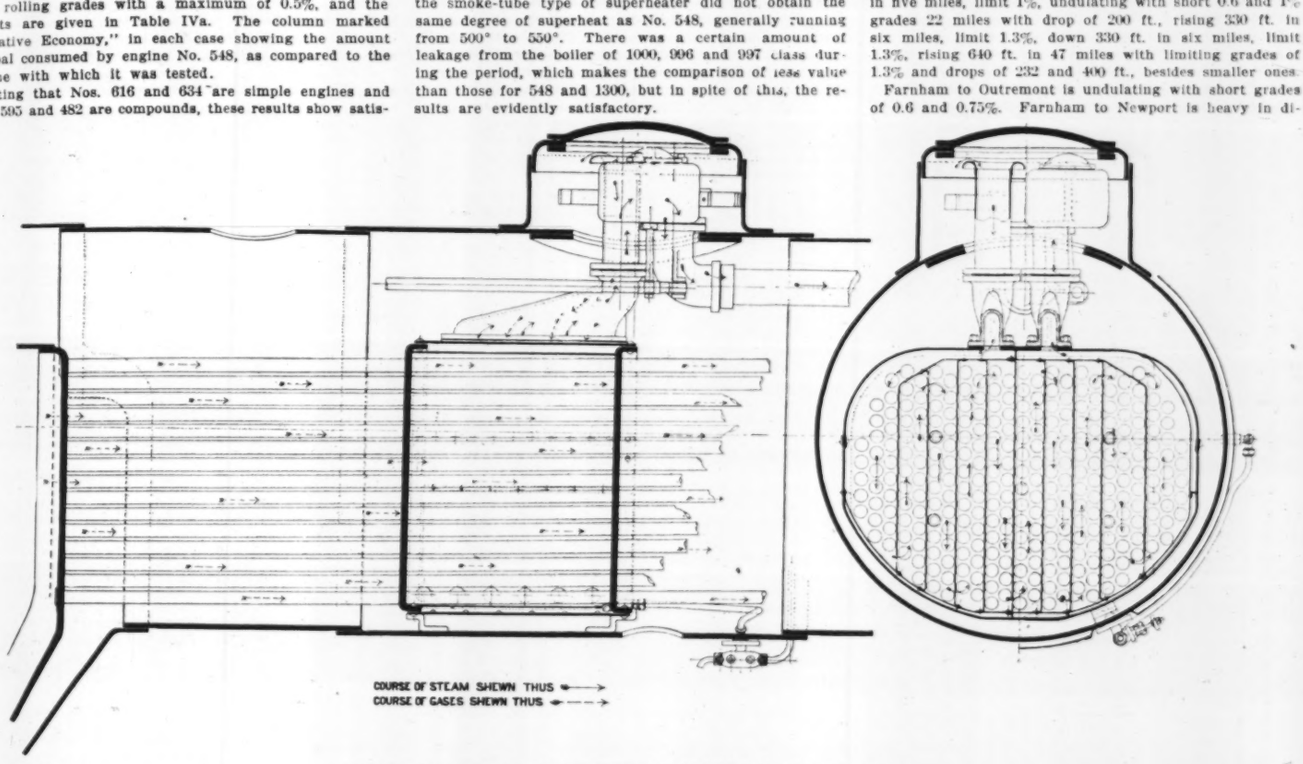


FIG. 8. PIELOCK'S SUPERHEATER, CANADIAN PACIFIC RY.

The results from 20 Schmidt smoke-tube superheaters and 21 Schenectady superheaters have been obtained over a period of four months. These engines could not be compared with similar engines, but they are compared with the 1300 class referred to previously and with a class of compound consolidations termed the 1200 class. As will be seen by the table below, these consolidations, although lighter, are a very similar engine in every respect to the superheaters, as they are comparative in their dimensions and have the same grate area and type of boiler. The dimensions of these engines are given in Table VI., the Schmidt superheater being the 1600 and the Schenectady superheater the 1621 class.

The results obtained from these engines are given in Table VIa., the number of engines working being the actual number of different engines of the class included in the figures each month and the comparative economy being that of the various engines compared with the 1200 class where possible, or if none of those engines were working, with the 1300 class, and in one case with the 1621 class. The column 1600 over 1621 shows the percentage of economy, or if negative, the loss of the 1600 over the 1621 class.

Reference has already been made to the nature of the divisions, Chalk River to North Bay, and North Bay to Cartier, shown in the above table; Cartier to Chapleau and Chapleau to White River are practically similar, having undulating grades with 1% limit, and a maximum rise or fall of 200 ft.; both divisions are, very largely, short grades, with very little level track, but the net rise is only 110 ft. in the latter case, and the former is practically level. Farnham to Megantic is a very heavy division in the direction of traffic, rising 750 ft. in 33 miles, with grades of 0.7 to 1.0%, undulating seven miles with drop of ten feet, limiting grades 1%, falling 135 ft. in five miles, limit 1%, falling 135 ft. in five miles, limit 1%, undulating with short 0.6 and 1% grades 22 miles with drop of 200 ft., rising 330 ft. in six miles, limit 1.3%, down 330 ft. in six miles, limit 1.3%, rising 640 ft. in 47 miles with limiting grades of 1.3% and drops of 232 and 400 ft., besides smaller ones.

Farnham to Outremont is undulating with short grades of 0.6 and 0.75%. Farnham to Newport is heavy in directions of traffic, rising 236 ft. in twenty miles, limiting grade 1%, 110 ft. in four miles with grades 1.4 and 1.66%, dropping 162 ft. in seven miles, 1% grades, undulating 18 miles, rising 422 ft. in 11 miles, 1.5% grades and dropping 255 ft. in four miles, 1.5% grades. Brownville to Mergantic in direction of traffic, rising 640 ft. in 15 miles with limit of 1.2%, dropping 700 ft. in 13 miles, grades up to 1.2%, undulating 58 miles with grades up to 1¼ miles long of 1.0%, dropping 480 ft. in 13 miles, 1%, undulating 11 miles, dropping 370 ft. in 7 miles, grade 1%.

From an inspection of this statement, which is simply an analysis of the regular road records for five months,

TABLE IV.—Dimensions of Canadian Pacific Locomotives.

Engine No.	548	616	595	634	482
Type	4—6—0	4—6—0	4—6—0	4—6—0	4—6—0
Kind	Simple S. H.	Simple	Compound	Simple	Compound
System	Schmidt S'box	.....	2-cylinder Pittsburg	.....	4-cylinder Vauclain
Cylinders	18 x 24	18 x 24	20 & 30 x 24	18 x 24	13½ & 23 x 24
Drivers	62″	62″	32″	62″	62″
Heating surface, fire tubes and firebox, square feet	1,116	1,291	1,291	1,428	1,614
Grate area	23.44	23.44	23.54	28.54	28.54
Boiler pressure, pounds	180	180	180	180	200
Weight on drivers, pounds	96,800	95,400	96,800	94,350	94,100
Total weight, pounds	124,000	119,250	123,400	119,325	129,225
Superheating surface, square feet	307	.....	.....	.....	.....

TABLE 1Va.—TESTS ON CANADIAN PACIFIC RAILWAY.

	Engine.	Engine, miles.	Ton-miles, Thousands.	Coal, tons.	Coal, per 1,000 ton-miles.	Relative Economy.
May, 1903, to December, 1903	548	34,493	33,183	1,541¼	93	81.5
Freight	482	31,857	30,457	1,741¼	114	100
January, 1904, to May, 1904	548	16,812	14,404	931	129	74
Freight	616	15,722	13,248	1,167	176	100
June, 1904, to September, 1904	548	15,768	2,451	467¼	382	81.5
Passenger	595	16,128	2,560	600	469	100
	634	16,854	2,750	680¼	495	105

it will be seen that the results obtained from the 1600 class are decidedly superior to those obtained from the 1621 class. This is due to the higher superheat in the former engine, which is about 100° as against 50° in the case of the latter; in neither is as much obtained as is desirable, but still good results have been obtained. The only case in which 1621 shows the better results is for a round trip in March, and it is not reasonable to place reliance in coal figures for one trip on account of no proper allowance being made for the coal on the tender. There is, however, a very general agreement that the 1621 class are equally as economical as the compounds and the 1600 class about 10% better, and while it is impossible to say definitely that this is due to the superheat, yet the fact remains that the 1200 and 1300 class engines were previously the most economical on fuel on the road and yet, as shown, the 1600 class have given superior results. No doubt, the experience so far gained is hardly sufficient for a definite conclusion, but it certainly can be said that the results to date are exceedingly satisfactory.

GENERAL CONCLUSIONS.

The use of superheated steam does not entail the multitude of practical difficulties that so generally accompany any invention or improvement that is introduced to improve the economic results obtained from a locomotive, and indeed, it is probable that as experience with its application develops, some of the expenses that are incurred in the locomotive of to-day will be diminished rather than increased .There would only appear to be two possible sources of additional cost, the wear of valves and cylinders due to defective lubrication, and the cost of maintaining the superheater itself. So far as has been learned at present, the lubrication of superheater engines is not different from that of other engines, with the exception that the lubrication must be accomplished, and it is not sufficient to hope that the oil gets to the designed spot. For this purpose a positive feed lubricator is required, and this should preferably be provided with six feeds, so that pipes may be led to each end of the valve and to the cylinder. It should also be possible to vary considerably the amount of oil fed per minute, as superheater engines, even more than those of the ordinary type, require more oil when working slowly at long cut-offs, than at other times, on account of the high temperature of the steam being maintained throughout the stroke. This can be effected either by supplementary oiling or by an easy adjustment of the lubricator allowing a large amount of oil to be fed at low speed, but the latter will be preferable if obtained without complication. With proper lubrication there appears to be no additional wear of valves or pistons, and while a special mixture of metallic packing must be used, it has given, if anything, less trouble on the superheaters than on the other engines. On Engine 548 in which the steam was superheated as high as 700°, it was found that the ordinary valve oil was not suitable and that the rod packings would melt out, but by reducing this from 550° to 600°, these troubles were not experienced, and no difference is noticed between an operation of this and an ordinary engine. The valves used on the 548 are Mr. Schmidt's design, but with split ring packing in place of the solid ring used in Germany, so that they are practically similar to the piston valves in general use, except in their being of small diameter, 6 in. for an 18-in. cylinder, and double ported. The packing rings, in place of being narrow, are comparatively wide and on the surface there are several water grooves. These rings have given exceedingly good service, but in view of the successful use of split rings it is difficult to see any reason why valves of the ordinary design should not be entirely suitable for superheated steam, the only point to consider being whether small double ported valves would not ge preferable to the large single ported valves at present in use, and whether wide rings with water grooves would not give better results than narrow plain rings. It is natural that, on account of the reduced weight of the superheated steam, a smaller admission area can be used than that required for saturated steam, but for equal flows under equal heads, the rate is only 10 to 9 and 8, for steam superheated 100° and 200° respectively, so that the dimensions adopted by Mr. Schmidt must be entirely ascribed to the use of double ported valves. Those engines on the Canadian Pacific having smoke-tube superheaters which have not developed the same degree of superheat as Engine 548, have given, so far, no trouble with their valves, pistons and packing, when properly lubricated, and while there is room for considerable improvement in positive feed lubricators before an entirely suitable design is obtained, it is safe to say that with proper lubrication there will be no greater expense in maintaining the engine on account of using superheated steam.

The repairs to the superheater proper are at present difficult to determine; the smoke-box superheater certainly entails an additional expense when flues are renewed, as it has to be entirely dismantled in order to get at the tube sheet, but while it is said to have given some trouble in service in Germany, such has not been the case in three years' experience on the Canadian Pacific Railway. Some trouble was at first experienced with the joint between the large tube and the back tube sheet, but this was overcome by properly thinning the edges of the lap, as in fire-box construction. There has been no leakage from the various joints in the front end and, in fact, so far nothing has developed that would lead to any additional expense in maintenance.

The smoke-tube superheaters of the Schmidt type have gives no trouble in service, but the arrangement of bolts and clips for securing pipe flanges to the headers is inconvenient, and it is quite difficult to make the joints perfectely tight to commence with; once tight, however, they do not appear to develop leakage and it seems probable that by the independent bolting now arranged for there will be no difficulty in this respect. In the Schenectady type there has been no trouble with the headers, but the ends of the superheater pipes toward the fire-box have blistered in a number of cases, due to the dampers not operating properly and allowing the pipe end to become overheated; this has been overcome by welding a solid plug into the end of the pipes, which should remedy the defect as in the Schmidt design, in which steel return bends are used; this action has not developed, as the metal is sufficiently thick to stand a considerable temperature without deforming when steam is admitted. The dampers must, however, be kept in an operative condition, as otherwise, when the blower is applied with a hot fire immediately after shutting off, the pipes may be subjected to an incense heat which is unsafe in view of their containing no steam. The 5-inch tubes have not been giving any especial trouble, in fact, they have lasted as well as the smaller tubes; this applies, of course, to good water districts and there is no available experience to determine whether, on bad water, they would stand up until the other tubes need renewal, but it is evident that their position in the flue sheets is favorable and the circulation around them is better than around the more closely spaced fire tubes.

As a matter of fact, it is too early yet to say anything definite about the expense of maintenance of superheaters; there is, of course, a possibility of a comparatively rapid deterioration of the pipes occurring, but there does not appear to be any immediate expense that will develop in one or two years' service. On the other hand there is the advantage of decreased evaporation for the same work, that occurs in compounds on account of their increased efficiency, and there is also an advantage in the dryness of the steam and reduced liability of water in the cylinder. On the smoke-box superheater with its high superheat, it is almost impossible to work water over into the cylinder excepting when first starting out before the apparatus has been

TABLE VI.—Dimensions of Canadian Pacific Locomotives.

	1200	1600	1621
Type	2—8—0	2—8—0	2—8—0
Kind	2-cyl. Compound	Simple S'heater	Simple S'he
System	Schenectady	Schmidt Smoke-tube	Schenectady Sm
Cylinders	22 & 35 x 28	21 x 28	21 x 28
Drivers	57″	57″	57″
Heating surface, fire tubes and firebox, square feet	2,218	2,381	2,870
Superheating surface	.....	375	340
Grate area	43.64	43.64	43.64
Boiler pressure, pounds	200	200	200
Weight on drivers, pounds	143,000	164,000	164,000
Total weight, pounds	162,000	186,000	186,000

TABLE V.—Dimensions of Canadian Pacific Locomotives.

Engine No.	1000	996 and 997	1300	1319
Type	4—6—0	4—6—0	4—6—0	4—6—0
Kind	Compound S. H.	Compound	Compound S. H.	Compound
System	2-cyl. Schmidt fire tube	Pittsburg 2 cyl.	2-cyl. Schenectady fire tube	2-cyl. Schenectady
Cylinders	22 and 35 x 26	22 and 35 x 26	22 and 35 x 30	22 and 35 x 30
Drivers	63″	62″	62″	62″
Heating surface, fire tubes and fire-box, square feet	1,888	2,420	2,492	3,065
Superheating surface, square feet	350	.....	390	.....
Grate area, square feet	33.02	33.02	44.08	44.08
Boiler pressure, pounds	210	210	200	200
Weight on drivers, pounds	129,000	128,000	141,000	141,000
Total weight, pounds	172,000	169,000	192,000	190,000

TABLE Va.—Tests on Canadian Pacific Railway.

	Engine.	Engine, Miles.	Ton-Miles, Thousands.	Coal, Tons.	Coal per 1,000 Ton-Miles.	Relative Economy.
Montreal to Smith's Falls.						
January, 1904, to July, 1904	1,000	21,567	25,321	1,271½	100	72
	997	19,662	23,278	1,499¼	129	100
August, 1904, to September, 1904	1,000	3,740	4,657	188½	81	70
	996	5,666	7,026	409¾	116	100
Chalk River to North Bay.						
November, 1903, to September, 1904	1,300	22,987	17,075	1,127½	132	90
	1,319	19,983	15,091	1,112½	147	100
North Bay to Cartier.						
November, 1903, to September, 1904	1,300	10,964	9,887	550¼	111	84
	1,319	10,521	9,249	616½	133	100

TABLE VIa.—Results Obtained on Can. Pacific

	Engine.	No. of Class Running.	Ton-Miles, Thousands.	Total Coal, Tons.	Coal per 1,000 E. G. Ton-Miles.	Relative Economy.	Relative 1621
Chalk River to North Bay.							
January	1200	12	7,077	717½	202	100	
	1300	1	805	80¼	199		
	1600	5	5,111	410⅝	160	79	21
	1621	9	10,669	1,075	201	100	
February	1200	1	202	17½	173	100	
	1300	1	1,354	117⅝	173	100	
	1600	6	7,542	612¾	162	94	14
	1621	8	8,728	824¼	188	100	
March	1200	1	316	24⅝	155	100	
	1300	1	770	56	145	93	
	1600	6	6,175	423¼	137	88	13
	1621	6	7,095	580¼	157	100	
April	1600	5	6,179	374⅜	121	93	7
	1621	6	9,886	645¼	130	100	
North Bay to Cartier.							
January	1200	10	6,393	499	156	100	
	1300	1	713	48½	136	87	
	1600	4	2,008	146	145	93	4
	1621	6	9,307	708⅝	152	97	
February	1200	2	1,590	137½	172	100	
	1300	1	565	44¼	156	91	
	1600	6	6,043	423¾	140	82	16
	1621	8	5,052	429	167	97	
March	1200	3	1,377	100¼	145	100	
	1300	1	728	50	137	95	
	1600	5	4,825	294	121	83	14
	1621	6	5,360	378½	141	97	
April	1200	1	365	26	143	100	
	1300	1	191	9¾	102	71	
	1600	5	6,322	367½	116	81	8
	1621	6	5,599	352¾	126	88	
Chapleau to White River.							
January	1300	3	3,755	340¼	181	100	
	1600	13	13,956	1,267¾	181	100	25
	1621	5	612	74¼	243	132	
February	1300	4	2,696	239	177	100	
	1600	9	13,226	1,050¼	158	89	
March	1300	3	4,821	400¼	164	100	
	1600	10	19,100	1,348	141	86	
April	1300	4	2,518	193	153	100	
	1600	9	11,894	738¾	124	81	
Cartier to Chapleau.							
January	1300	3	3,373	322¾	191	100	
	1600	11	14,547	1,209¼	166	87	12
	1621	7	1,170	110¼	188	98	
February	1300	3	3,979	332¾	167	100	
	1600	9	13,176	996¾	151	90	
March	1300	3	3,305	246¼	149	100	
	1600	11	21,942	1,450	136	91	6
	1621	1	265	17	128	86	
April	1300	3	2,726	204¾	150	100	
	1600	9	12,814	766¾	119	79	
Megantic to Farnham.							
January	1200	6	759	124¾	328	100	
	1621	7	13,595	2,164½	318	97	
February	1200	4	879	177¼	403	100	
	1621	7	12,639	2,060½	326	81	
March	1200	1	170	32	378	100	
	1621	8	15,481	2,153¾	278	74	
April	1200	1	1,033	152¼	295	100	
	1621	8	13,928	1,820¼	261	89	
Farnham to Outremont.							
January	1200	8	1,120	126¼	225	100	
	1621	4	1,800	186	206	92	
February	1200	4	1,754	211	240	100	
	1621	7	801	105½	263	109	
March	1200	2	1,228	112¾	188	100	
	1621	3	821	88	202	110	
April	1200	1	49	5½	224	100	
	1621	1	52	6	230	102	
Newport to Farnham.							
January	1200	4	611	102¼	334	100	
	1621	6	1,807	261¾	289	87	
February	1200	2	946	137	289	100	
	1621	4	1,184	177¾	300	104	
March	1200	2	1,036	148¼	286	100	
	1621	1	282	37¼	264	92	
Brownville to Megantic.							
January	1200	12	5,364	667	252	100	
	1621	6	12,113	1,429¾	236	94	
February	1200	12	6,991	982¼	281	100	
	1621	6	4,886	801¾	342	122	
March	1200	12	7,907	949¼	240	100	
	1621	4	9,447	1,064	225	94	
April	1200	14	6,319	720¼	228	100	
	1621	4	7,837	923¾	235	103	

d up, and while this is not the case to the same with moderate superheaters, it is an advantage to ain degree.

ossible advantage of superheating has not been d in its application in America, namely, a reduc- boiler pressure without loss in efficiency, although rmany this has been usual. There is no doubt the increase of pressure from 175 to 200 and 210 that has taken place within the last few years has of doubtful advantage. While there is a gain in omy, this is accompanied by an increase in the s due to leakage, both in engine and boiler, and by onsiderable increase in the cost and trouble of boiler tenance. By superheating, the initial pressure be- es of less importance and with the proper amount of erheat, it will be possible to return to pressures of lbs. or less, without any appreciable loss in econ- y, and with a relief from those boiler troubles, which e become more serious as the pressure has increased, it is probable that the saving from this cause alone will overbalance any additional expense connected with the maintenance of the superheater.

Herr Garbe, in addition to the reduction of boiler pressure, advocates a still further advance, namely, the enlarging of the cylinders sufficiently to develop the full power of the engine, with cut-offs of 30 to 33%. A reduction in power is then effected chiefly by throttling, the cut-off remaining practically constant. This method may possibly prove advisable in American passenger work, but it does not appear practicable for freight locomotives. It is evidently impossible to develop the same tractive power with a given weight on drivers, with a cut-off of 30% as with 80%, since there is a greater variation in the maximum effort in the former case, and with the conditions here prevalent, where the loading is so closely equal to the capacity of the engine, a reduction in capacity could not be tolerated. A reduction in boiler pressure, however, when accompanied by a corresponding increase in the cylinder dimensions, does not affect the tractive power and would appear to be a decided advantage.

In general, therefore, it may be assumed that the maintenance of locomotives using superheated steam will not be necessarily greater than that of ordinary locomotives of similar size, as although certain additional expenses are introduced, these are offset by economies in other directions, and the net result will not be very much different. If this position is correct, the advisability of superheating depends entirely on the relation between the initial additional cost and the saving obtained, and as, at present, the cost of applying a superheater is about $1,000 per engine, and the tendency will be rather to reduce this amount than increase it, it is evidently a very good investment. A 200,000-lb. freight engine making 30,000 miles per annum, will burn about 2,500 tons of coal, which at $2 per ton, costs $5,000, so that evidently a saving of 10% will pay 50% of the additional cost per annum, and it appears perfectly safe to state that with a superheater at least that amount can be saved. When slightly more expensive, at first cost, than compounding, there is in the application of superheated steam a possible development in locomotive engines, and without complication in its construction, which costs no extra for maintenance, does not reduce the efficiency of a locomotive in any way as a mover of freight, and which, without any desire to appear too enthusiastic, certainly promises to become one of the greatest steps in the direction of economy that has been introduced for many years past.

DISCUSSION.

Prof. W. F. Goss (Purdue University) wished to testify his appreciation of the great value of the paper, and felt sure that it would contribute greatly to the advancement of our practice in superheating. In response to questions by Mr. F. M. Whyte (N. Y. C. & H. R.) the author stated that his experience covering a considerable period during which careful records were kept, was such that he felt justified in giving the round figures of 10% saving in coal as the result of superheating. Mr. Angus Sinclair desired to call a warning against being too sanguine concerning economies to be gained by superheating; only the test of real service over a long period would show what actual results could be expected. Mr. T. Rumney (Erie) had in service two locomotives equipped with superheaters which he was comparing in actual operation with an engine of the same type not so equipped, but he did not yet have sufficient data to warrant results being stated. The opinion of the engineer, however, was that great economy resulted from the use of superheaters. Mr. W. Cross (Canadian Pacific) stated that he made the first test with superheater engines on the Canadian Pacific Ry. Every car in the train was weighed and every pound of coal was weighed. The economy shown over non-superheating was in round figures 30%. This figure induced the company to go extensively into the use of superheaters with the results given in the paper. He wished to insist that these results were as accurately and uniformly based as possible. In closing the discussion, Mr. Vaughan stated that about all he had to say further was that by the end of this year the Canadian Pacific would have 106 of the engines in service equipped with superheaters, so it was apparent that whether the company's judgment was good or bad, it at least thought that it was on the right track.

STANDARD SPECIFICATIONS FOR LOCOMOTIVE FORGINGS.*

SPECIFICATION FOR DRIVING AND ENGINE TRUCK AXLES.

Material.—Open-hearth steel.

Chemical Requirements.—Phosphorus, not to exceed .05%; sulphur, not to exceed .05%; manganese, not to exceed .60%.

Physical Requirements.—Tensile strength—not less than 80,000 lbs. per sq. in.; elongation in 2 ins—not less than 20%; reduction in area—not less than 25%.

Tests.—One test per melt will be required, the test specimen to be taken from either end of any axle with a hollow drill, half-way between the center and the outside, the hole made by the drill to be not more than 2 ins. in diameter nor more than 4½ ins. deep. The standard turned test specimen, ½-in. in diameter and 2 ins. gage length, shall be used to determine the physical properties. Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

Stamping and Marking.—Each axle must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜-in. high, and have order number plainly marked with white lead.

Inspection.—All axles must be free from seams, pipes and other defects, and must conform to drawings accompanying these specifications. Axles must be rough-turned all over, with a flat-nosed tool, cut to exact length, have ends smoothly finished and centered with sixty-degree centers. Axles failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

SPECIFICATIONS FOR FORGINGS.

Material.—Open-hearth steel.

Chemical Requirements.—Phosphorus, not to exceed .05%; sulphur, not to exceed .05%; manganese, not to exceed .60%.

Physical Requirements.—Tensile strength—not less than 80,000 lbs. per sq. in.; elongation—not less than 20% in 2 ins.; reduction in area—not less than 25%.

Tests.—One test per melt will be required, the test specimen to be cut cold from the forging, or full-sized prolongation of same, parallel to the axis of the forging and half-way between the center and the outside. The standard turned specimen, ½-in. in diameter and 2 ins. gage length, shall be used to determine the physical properties. Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

Stamping and Marking.—Each forging must have heat number and name of manufacturer plainly stamped on one end with figures not less than ⅜-in. high, and have order number plainly marked with white lead.

Inspection.—All forgings must conform to drawings which accompany these specifications, and be free from seams, pipes and other defects. Any forgings failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

SPECIFICATIONS FOR STEEL BLOOMS AND BILLETS FOR FORGINGS.

Material.—Open-hearth steel.

Physical Requirements.—Grade "A": Tensile strength, 70,000 lbs. per sq. in.; elongation in 2 ins., 20%. Grade "B": Tensile strength, 80,000 lbs. per sq. in.; elongation in 2 ins., 17%.

Chemical Analysis.—Grade "A":

Carbon	.25 to .40%
Phosphorus, not to exceed	.06%
Sulphur, not to exceed	.06%
Manganese, not to exceed	.60%

Grade "B":

Carbon	.35 to .50%
Phosphorus, not to exceed	.05%
Sulphur, not to exceed	.05%
Manganese, not to exceed	.60%

Tests.—One test per melt will be required, the test specimen to be cut cold from the bloom, parallel to its axis and half-way between the center and the outside. The standard turned test specimen, ½-in. in diameter and 2 ins. gage length, shall be used to determine the physical properties. Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

Stamping and marking.—Each bloom or billet must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜-in., and have order number plainly marked with white lead.

Inspection.—Blooms and billets must be free from checks, pipes and surface defects. Any blooms or billets chipped to a depth greater than ½-in. will be rejected. Any billet or bloom failing to meet the above requirements will be rejected and held subject to disposal by manufacturers. Inspector to have the privilege of taking drillings from the center of the top bloom or billet of the ingot in order to determine the amount of segregation. Grade "A" is intended for rod straps and miscellaneous forgings. Grade "B" is intended for driving and truck axles, connecting rods, crank pins and guides.

*Committee report presented to the American Railway Master Mechanics' Association at Manhattan Beach, N. Y., June 14-16, 1905.

COUNTERWEIGHTS FOR LARGE ENGINES.*

By D. S. Jacobus, M. Am. Soc. M. E.†

The writer was called upon to investigate the problem of lessening the vibration of the engines at the new power plant at the Manchester St. station of the Rhode Island Co., Providence, R. I., and working conjointly with Mr. Fred N. Bushnell, the chief engineer of the company, he recommended that certain counterweights be added in addition to those already on the engines. These counterweights, which were exceptionally large, were adopted and gave satisfactory results.

In addition to the problem of lessening the vibrations certain electrical problems arose regarding the effect of the counterweights in increasing the variation in angular velocity of alternating current generators run in parallel with each other. A number of measurements were made to determine the action of the counterweights, both as affecting the vibration of the building and the tendency of the alternating current generators to break apart when run in parallel, and as this data may be of interest to the society it is hereby presented.

The counterweights were applied to three engines, all of which were of the same cylinder dimensions and had the same weights of reciprocating parts. The engines were built by the Filer & Stowell Co. of Milwaukee, Wis., and were of the horizontal cross-compound type directly connected to electrical generators. Two of the engines, designated as Nos. 1 and 2, were connected to 1,500 KW. alternating current generators, and one, designated as No. 3, to a 1,000-KW. direct current generator.

On inspecting the plant it was evident that something should be done to diminish the shaking. The entire building rested on piles which passed through silt for about 30 ft. before striking a solid bottom. There was a mass of concrete about 5 ft. thick placed on these piles which extended under the entire plant so as to form a bed on which rested the foundations of the buildings, boilers and engines. The bed of concrete also extended under the chimney foundation. When the first observations were made the buildings were not completed. All three engines were, however, installed and were protected by a temporary wooden structure. The boiler plant was in the process of construction, much of the brick work having been laid, and the steel framework of the building nearly completed. A portion of the boiler plant was running to supply steam to one of the engines. The chimney, which was ultimately to be about 30 ft. high, was being erected. This was built of special brick furnished by the Alphons Custodis Chimney Construction Co.

The engine which was running was that designated as No. 3, and it shook the entire foundation to such an extent that the motion could be readily felt by a person standing thereon. When water was poured outside of sheet piling, which surrounded the foundation, the surface of the water could be seen to move up and down in time with the strokes of the engine.

After inspecting the plant the writer constructed an apparatus on the principle of the seismograph for measuring the amount of vibration. On a second visit to the plant the horizontal shake of the foundation was measured with this instrument with engine No. 3 running, and found to be 0.01-in. at the engine. This may not seem to be a large amount, but as the entire mass of the building foundation shook, the movement of parts of the temporary wooden building was magnified in many places so as to be very evident to the eye. Furthermore, the iron work of the boiler house shook considerably. That the entire mass of the foundation shook could be appreciated by feeling the vibration through the feet and also by measuring the actual amount at different points with the special apparatus. At a point near the extreme end of the foundation where the No. 1 engine was located the foundation was found to shake 0.008-in. Measurements made near the top of the chimney, which was erected to the height of about 175 ft. above the ground, showed that the maximum shake with the engine running at its ordinary speed of 90 revolutions per minute was about 0.02-in. After measuring the vibration of the chimney with the engine running at its ordinary speed the engine was shut down and a marked result took place when its speed fell in harmony with the time of vibration of the chimney. When this occurred, the chimney shook to such an extent that the motion was beyond the range of the special instrument. The total movement of the pointer of the instrument was such that the chimney was shown to move more that ¼-in. In constructing the chimney the workmen had noticed that when they came to a height of about 130 ft., the vibration was much greater than it was after the chimney was built higher. This made it appear that at the height of 130 ft., at which there was the most shake, the time of the vibration of the chimney was in harmony with the number of revolutions made by the engine.

As the entire plant shook laterally on top of the piles, and as there could be no vertical movement, it appeared

*A paper presented at the Scranton meeting of the American Society of Mechanical Engineers.

†Professor of Experimental Mechanics, Stevens Institute, Hoboken, N. J.

evident that the best plan would be to place counterweights on the engines of such sizes that they would diminish the horizontal shaking forces to nearly a minimum irrespective of the vertical shaking forces which might be produced. This would give much larger counterweights than are ordinarily used, but on carefully considering the conditions which existed it was deemed best to adopt them. The counterweights originally on the engines were comparatively small and it was found impossible to place large enough weights on the crank disks to carry out this plan. It was, therefore, decided to place counterweights on the fly-wheels in addition to placing as heavy counterweights as possible on the crank disks. A counterweight in the fly-wheel acts just as efficiently as one placed on the crank disk in eliminating the shaking forces tending to translate the bed of the engine, but with such a counterweight there remain forces which act as couples and tend to shake the engine by rotating it about its center of mass. The horizontal forces tending to produce translation were, however, the most important in the case under consideration, and these were considered irrespective of the forces tending to produce rotation.

The weight of the counterweights recommended to be added in addition to those already on the No. 3 engine was 4,935 lbs. on each of the crank disks and 3,600 lbs. in the fly-wheel, the distance of the center of gravity of the weights on the crank disks from the center of the shaft being 2.38 ft. and for the weight in the fly-wheel 7.67 ft. The counterweights originally in each crank disk amounted to a net weight of 1,740 lbs. at 2.05 ft.

The position of the fly-wheel counterweight and the shaking forces with and without the additional counterweights are shown in Fig. 1.

Mr. Bushnell designed counterweights for the No. 3 engine to conform with the above sizes. The counterweights finally placed on the engine were somewhat lighter than called for, but not enough so to produce any great difference in the results. On starting up the No. 3 engine with these counterweights it ran without appreciable vibration and operated with entire satisfaction.

Counterweights were then placed on engines Nos. 1 and 2 driving the alternating current generators. As the dimensions of these engines and the weights of the reciprocating parts were the same as for the No. 3 engine, the same size of counterweights were used as for the latter, but those placed in the revolving fields were necessarily

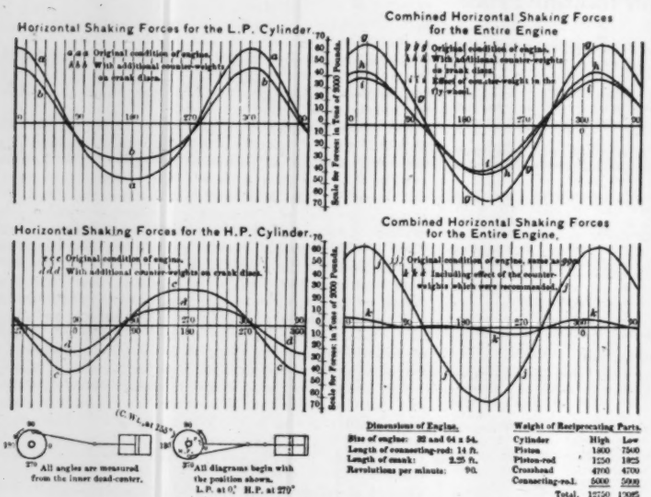

Horizontal Shaking Forces for the L.P. Cylinder.
Combined Horizontal Shaking Forces for the Entire Engine
Horizontal Shaking Forces for the H.P. Cylinder.
Combined Horizontal Shaking Forces for the Entire Engine.
All angles are measured from the inner dead-center.
All diagrams begin with the position shown. L.P. at 0° H.P. at 270°
Dimensions of Engine.
Size of engine: 32 and 64 x 54.
Length of connecting-rod: 14 ft.
Length of crank: 2.25 ft.
Revolutions per minute: 90.
Weight of Reciprocating Parts.
Cylinder High 1800 Low 7500
Piston 1250 1825
Piston-rod 4700 4700
Crosshead 5000 5000
Connecting-rod
Total 12750 19025

FIG. 1. DIAGRAMS OF HORIZONTAL SHAKING FORCES IN ENGINE NO. 3.

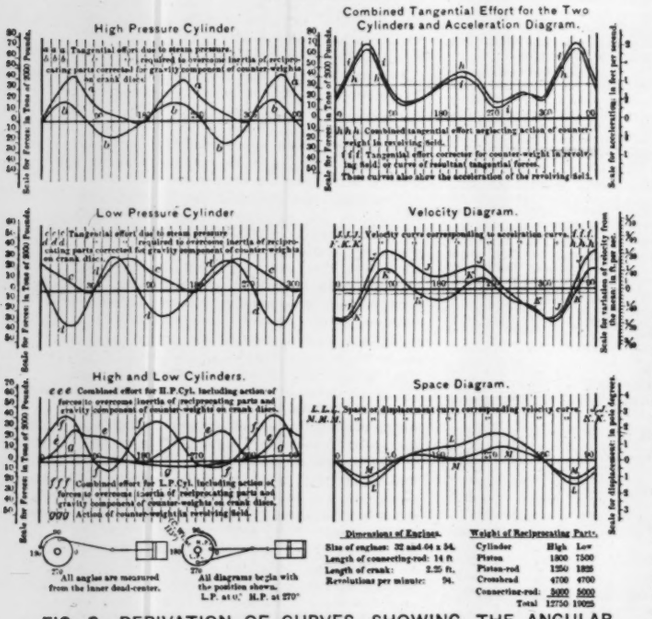

High Pressure Cylinder
Combined Tangential Effort for the Two Cylinders and Acceleration Diagram.
Low Pressure Cylinder
Velocity Diagram.
High and Low Cylinders.
Space Diagram.
All angles are measured from the inner dead-center.
All diagrams begin with the position shown. L.P. at 0° H.P. at 270°
Dimensions of Engines.
Size of engines: 32 and 64 x 54.
Length of connecting-rod: 14 ft
Length of crank: 2.25 ft.
Revolutions per minute: 90.
Weight of Reciprocating Parts.
Cylinder High 1800 Low 7500
Piston 1250 1825
Piston-rod 4700 4700
Crosshead 4700 4700
Connecting-rod: 5000 5000
Total 12750 19025

FIG. 2. DERIVATION OF CURVES, SHOWING THE ANGULAR VARIATION OF REVOLVING FIELDS OF ALTERNATORS IN POLE DEGREES.

per minute. The amount that the floor shook was measured and was found to be extremely small and .002-in.

The ground was frozen during the above te... was decided that it would be best to make a fi... observations of the amount of shaking after the ... entirely out of the ground. Furthermore, some ... arose as to the possible danger of the alternati... generators breaking out of step when run in ... with their field counterweights opposed, becaus... run, the ammeters attached to the generators sw... siderably, indicating fluctuations in the curr...

On looking through the magnets of the revolv... of one of the alternating current generators at th... ing field of the other the angular variation back ...

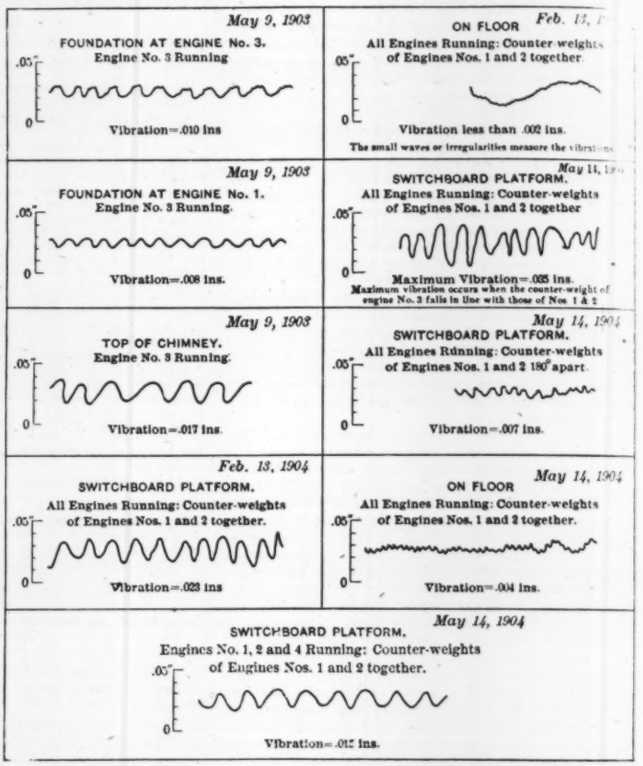

May 9, 1903
FOUNDATION AT ENGINE No. 3.
Engine No. 3 Running
Vibration=.010 ins
Feb. 13, 1
ON FLOOR
All Engines Running: Counter-weights of Engines Nos. 1 and 2 together
Vibration less than .002 ins.
The small waves or irregularities measure the vibrations
May 9, 1903
FOUNDATION AT ENGINE No. 1.
Engine No. 3 Running.
Vibration=.008 ins.
May 14, 190
SWITCHBOARD PLATFORM.
All Engines Running: Counter-weights of Engines Nos. 1 and 2 together
Maximum Vibration=.035 ins.
Maximum vibration occurs when the counter-weight of engine No. 3 falls in line with those of Nos 1 & 2
May 9, 1903
TOP OF CHIMNEY.
Engine No. 3 Running.
Vibration=.017 ins.
May 14, 1904
SWITCHBOARD PLATFORM.
All Engines Running: Counter-weights of Engines Nos. 1 and 2 180° apart.
Vibration=.007 ins.
Feb. 13, 1904
SWITCHBOARD PLATFORM.
All Engines Running: Counter-weights of Engines Nos. 1 and 2 together.
Vibration=.023 ins
May 14, 1904
ON FLOOR
All Engines Running: Counter-weights of Engines Nos. 1 and 2 together.
Vibration=.004 ins.
May 14, 1904
SWITCHBOARD PLATFORM.
Engines No. 1, 2 and 4 Running: Counter-weights of Engines Nos. 1 and 2 together.
Vibration=.012 ins.

FIG. 3. DIAGRAM SHOWING VIBRATIONS AT VARIOUS PLACES IN POWER HOUSE.

of a different form than that employed in the fly-wheel of the No. 3 engine. In these engines the high pressure crank leads; whereas, the low pressure leads in the No. 3 engine, and this was taken account of in placing the counterweights in the revolving fields.

There was some delay in arranging for a third visit to the plant. The buildings and the chimney of the plant were then completed. A vertical engine directly connected to a 2,500 KW. generator had been erected and was running in addition to the three horizontal engines. It was found that the greatest shaking that could be noticed occurred on the switchboard platform which was anchored to one of the side walls of the building at a point some distance above the floor. When engines Nos. 1 and 2 driving the 1,500 KW. alternators were run in parallel with the counterweights opposed they produced but little vibration. When run with the counterweights together there was a greater vibration. The greatest vibration that could be detected on the switchboard platform with the counterweights of the two alternating machines together and all the engines in the station running, including Nos. 1, 2 and 3, and a vertical engine which is designated as No. 4, was about .023-in. This maximum shake occurred when the counterweights of the three engines Nos. 1, 2 and 3 fell together, which would take place about once every 15 seconds, as the two engines running the alternators ran at about 94 revolutions per minute and that driving the direct current machine at 90 revolutions was apparent. This was carefully estimated and under the ordinary conditions of running was found to amount to from about 6 to 8 pole degrees total variation or from about 3 to 4 pole degrees for each machine. The amount of this angular variation with the machines running in parallel was about the same irrespective of the position of the counterweights with reference to each other, but when the counterweights were opposed the variations occurred every stroke or about 94 times per minute; whereas, when the counterweights were together, or nearly so, the variations occurred at less frequent intervals, the total number of such variations then being from about 30 to 40 per minute. As the total displacement of the two fields from their true position, as observed by looking through the magnets of one revolving field at the other, was about the same irrespective of the relative positions of the two counterweights, it follows that this displacement was produced as much through governor action as through any variation in speed during a single stroke.

When the two alternating machines were operating in parallel there was a swaying of the ammeters in the machine circuits. This swaying was, however, of an entirely different frequency from that of the strokes of the engines. The amount of this swaying was noted for different relative positions of the counterweights of the engines. The engines were operating at the time under light loads. The voltmeter reading was also noted and found to be steady in every instance.

It appeared that the fluctuations in the current generated by the two alternating machines had but little influence on their efficiencies and that they were working successfully when connected in parallel. The writer did not wish, however, to give an opinion on the electrical side of the problem and arranged with Prof. Albert F. Ganz, Professor of Electrical Engineering of Stevens Institute, to accompany him at the time of making the final measurements.

...joint visit of Professor Ganz and the writer, observ... of the angular displacement of the rotating fields ...tical readings were again taken and these observ... led Professor Ganz to conclude that there was no ... danger of the alternators breaking out of step ... operating in parallel with the counterweights in ...ative position.

...al measurements were also made at this time ... amount that the engine shook the building. Ob... of the angular displacement of the revolving ... when run in parallel bore out in a general way those ... on my previous visit.

...der to study more thoroughly the effect of the ...weights in increasing the angular variation, dia... of crank efforts were laid off corresponding to in... cards taken from the engines and from these ... of crank effort the angular variation in pole de... was determined, as shown in Fig. 2. From this ... it may be seen that the variation for a single ma... without the addition of the counterweights in the ...ving fields would be 1.8 pole degrees, and with the ...counterweights 3.2 pole degrees. The latter value is the ... to be compared with the variations observed by look... through one of the revolving fields and observing the ... and it agrees with the amount which was ob... served, which varied from 3 to 4 pole degrees.

It appears from Fig. 2 that by placing the counterweights in the revolving fields the angular variation during a single stroke is made about twice what it would have been without the counterweights. It however appears that the increased angular variation during a single stroke due to employing the counterweights does not introduce any great disadvantage as the alternators can be safely run in parallel at practically the same efficiency as would exist should there be less angular variation.

As already stated the counterweights actually placed in the engines were of a less weight than the amounts called for but not enough so as to produce any great difference in the results obtained. They were also placed at different radii from those called for. The weights of the counterweights and their distances from the center of the shaft which were recommended and which were actually used as follows: For comparing these the product of the weights into the distances of their centers of gravity from the center of the crank shaft are given as these products are a measure of the effects produced on the shanking forces.

	Recommended.	Actually used.
Engines Nos. 1 and 2 driving alternating current generators:		
Counterweights placed on crank disks..	4,995	4,100 lb.
Counterweights placed in revolving fields	3,600	3,467 "
Distance of center of gravity of the weight in the revolving fields to the center of the shaft	7.67	7.56 ft.
Distance of center of gravity of the weights on the crank disks to the center of the shaft.....	2.38	2.77 "
Product of weight in tons by the distance in ft.:		
Crank disks counterweights.....	5.94	5.68 "
Revolving field counterweights.....	13.81	13.11 "
Engine No. 3 driving direct current generator:		
Counterweight placed on crank disk of high-pressure cylinder	4,995	4,100 lb.
Counterweight placed on crank disk of low-pressure cylinder	4,995	4,180 "
Counterweight placed in fly-wheel.....	3,600	3,600 "
Distance of center of gravity of weight in the fly-wheel to the center of the shaft.	7.67	7.06 "
Distance of center of gravity of the weights on the crank disks to the center of the shaft	2.38	2.77 "
Product of weight in tons by the distance in ft.:		
Crank disk (high-pres. cyl.).....	5.94	5.68
Counterweights (low-pres. cyl.).....	5.94	5.79
Fly-wheel counterweights	13.80	12.71
Weight of original counterweights on crank disks of all the engines.....	.....	1,740 lb.
Distance of center of gravity of the original counterweights from the center of the shaft	.....	2.05 ft.

Fig. 3 shows characteristic records taken with the special instrument for measuring the amount of shake. The principle on which this instrument was constructed is shown in Fig. 4. A light Pointer A was made to rest against a large mass suspended from a point at some distance above. In most of the experiments this mass was the lower block of the hoist of a traveling crane. This large mass was not affected by the vibrations of the building, or if affected its vibrations had a different period from those to be measured. The instrument was mounted at a part of the building where the vibration was to be measured and therefore moved in the same way as the building. In taking a record the drum B was revolved by hand by pulling the cord C and a curve was traced by a pen D on a paper placed on the drum B. The width of the diagram traced by the pen represented the amount of vibration. In the diagrams the vibrations were magnified fifteen times. The fact that the cylinder was rotated by hand accounts for some of the irregularities in the curves, but this does not affect the accuracy of the records which depend only on the width of the waves measured from the top of one to the bottom of the one next following.

It may be seen from Fig. 3 that the amount of vibration was greater at the time of the last visit than it was when measured on Feb. 13. This is accounted for by the fact that the ground about the building was frozen on Feb. 13, whereas such was not the case when the final measurements were made. The final measurements gave 0.035 in. for the maximum vibration of the switchboard platform with all the engines running and with the counterweights of engines Nos. 1 and 2 together. The movement of the floor of the engine room and of the foundation for this set of conditions was 0.04 in. The amount that the foundation shook with the No. 3 engine running alone without counterweights, as measured on the first visit, was 0.01 in. It therefore follows that there was less than one-half the amount of vibration with all three engines running with their counterweights in such a position that they gave the maximum shake than there was with a single engine running without the additional counterweights.

After the above investigation was completed Mr. Bushnell made observations with a transit to determine whether there was any shaking of the chimney with all the engines running and found that there was no perceptible motion.

METHOD OF COMPUTING THE SIZE OF COUNTERWEIGHTS REQUIRED.

To most nearly balance the horizontal shaking forces in one of the engines a counterweight equivalent to the entire mass of the reciprocating parts with its center of gravity at the crank radius should be used. It was impossible to place such a mass on the crank disk, and, as has already been stated, as heavy counterweights as possible were placed on the crank disks and an additional counterweight was placed either in the fly-wheel or in the revolving field.

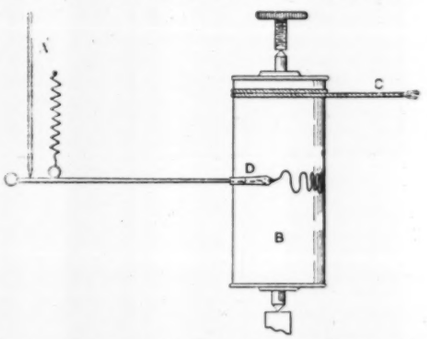


Fig. 4. Instrument for Graphically Recording Vibrations.

The maximum counterweights which could be placed on the crank disks were estimated at 4,995 lbs. at 2.38 ft. The counterweights originally on the engines amounted to 1,740 lbs. at 2.05 ft., so that the counterweights originally on the crank disks, together with the counterweights added to the crank disks, amounted to 6,870 lbs. at the crank radius. As the total weight of the reciprocating parts amounted to 12,750 lbs. for the high pressure cylinder and 19,025 lbs. for the low pressure cylinder there remained 5,880 lbs. at the crank radius to be provided for by counterweight action in the high pressure cylinder and 12,155 lbs. at the low pressure cylinder. To accomplish this action a counterweight should be placed in the fly wheel of 3,960 lbs. at 7.67 ft. from the shaft center. For the direct current generator where the low pressure crank leads this counterweight should be placed about 155° ahead of the low pressure crank, and for the alternating current generators where the high pressure crank leads it should be placed about 115° ahead of the high pressure crank.

The full counterweight was not, however, recommended, as a substantial balance of the horizontal forces would be obtained by employing a weight of 3,600 lbs. in the fly-wheels or revolving fields instead of 4,000 lbs., and it was considered advisable to keep slightly within the theoretical limit.

In plotting the shaking forces given in Fig. 1 the gravity component of the rod at the crank pin end is assumed to revolve with the crank pin and the remainder to have the same motion as the piston.

As the distance of the center of gravity of the rod from the crank pin was 46% of the length of the rod, this gave 2,700 lbs. for the revolving part at the crank pin and 2,300 lbs. for the part which was assumed to move with the piston. This gives correct results as far as the shaking forces are concerned. In obtaining the horizontal shaking forces for the counterweights the centrifugal force is multiplied by cos θ where θ is the crank angle measured from the line of centers. For the mass moving along with the piston the horizontal shaking forces were obtained by the formula*

$$F_2 = m r^2 R (\cos \theta + Z)$$

where Z can be given the approximate value of

$$\frac{\cos 2\theta}{n}$$

METHOD OF DETERMINING THE ANGULAR DISPLACEMENT OF THE REVOLVING FIELDS OF THE ALTERNATING CURRENT GENERATORS WHEN RUN IN PARALLEL.

This work is represented by the curves shown in Fig. 2. The tangential effort curves due to the steam pressure which are there given were obtained from indicator cards taken from the engines. The effect of the inertia of the connecting rod on the tangential effort is obtained by assuming that one-half of the mass of the rod is concentrated at the crank pin and one-half at the crosshead.* The inertia forces are worked out by the formula already given and the tangential effort is worked out in the ordinary way. The effect of the gravity components of the counterweights was included in the analysis. Two sets of results were worked out, one for the engines as they are now running with the counterweights which were added, and one assuming that the counterweights in the revolving fields were removed.

The final curve of tangential effort for the entire engine if measured on the proper scale represents the acceleration. This scale was determined as follows:

The fly-wheel action of the revolving parts amounted to 2,236,000 lbs. at the crank radius.

The scale of the ordinates of the diagrams as originally constructed was 64,000 lbs. per in. and the ordinates were ¼-in. apart, each space representing 15° of crank angle.

The acceleration corresponding to one inch height of the ordinates was therefore

$$64{,}000 \times 32.2 \div 2{,}236{,}000 = 0.922 \text{ ft. per second,}$$

which gave the scale laid off to the right of the acceleration diagram.

The areas included between each two consecutive ordinates of the acceleration diagram were measured in square inches and this area gave the increments in velocity for the velocity diagram.

In laying off the increments in the velocity diagram the number of square inches were multiplied by two and laid off in lineal inches. If f represents the acceleration, $\triangle$ t the time corresponding to the distance between two of the ordinates, or for the crank to turn 15 degrees, and $\triangle$ v the variation in the velocity, we have

$$f \triangle t = \triangle v.$$

As the crank revolved at 94 turns per minute, we have

$$\triangle t = 60 \div (94 \times 24) = .0266 \text{ sec.}$$

As the space between the ordinates of the acceleration curve was ¼-in. and the scale of the ordinates .922 ft. per sec., the value of f would be obtained by multiplying the area between two of the ordinates by .922 × 4 or by 3.688, hence we have

$$\triangle v = \text{Area between two ordinates} \times .0266 \times 3.688 = .0981.$$

The area between the ordinates was multiplied by 2 in laying off the increments in the velocity diagram, hence for one inch of height in the velocity curve would be

$$.0981 \div 2 = .0491 \text{ feet per second.}$$

The areas measured in square inches on the velocity diagram were laid off directly in lineal inches in the space diagram. The scale for this diagram was therefore

$$4 \times 0.0491 \times 0.0266 = 0.00522 \text{ ft. per inch of height.}$$

To obtain the scale in pole degrees the circumference of the crank circle or 14.14 ft. was divided by 16, the number of poles and the distance measured between the poles at the crank circle was found to be 0.884 ft. The distance per pole degree was

$$0.884 \div 360 = 0.00246 \text{ ft.}$$

The scale of the diagram in pole degrees per inch was therefore

$$0.00522 \div 0.00246 = 2.12.$$

*For notation and formula see article by the author. Transactions of the American Society Mechanical Engineers, Vol. II., pages 513 and 515.

*This is the way recommended by Mr. Sanford H. Moss in a paper presented at the last meeting of the society.

THE SAN PEDRO, LOS ANGELES & SALT LAKE RY.

The completion of the San Pedro, Los Angeles & Salt Lake Ry. marks the realization of a project which has a history covering more than 25 years. Previous to 1880, the Union Pacific Ry. built a line running southwest from Salt Lake City to Milford, Utah, 260 miles, to open communication with settlements in southern Utah and Nevada, and with a view to an ultimate extension through to California. In 1880 a 17-mile branch line was built from Milford to a silver mining settlement at Frisco, Utah, and this has since been extended to Newhouse. In 1889-90 an extension from Milford to Pioche, Nev., was surveyed and a large amount of grading was done, the intention being to eventually continue the line to Los Angeles. In 1890, owing to financial conditions, the work was abandoned, and the company never completed its title to the right-of-way. In 1896, the Milford line and other lines were separated from the Union Pacific Ry. and organized as the Oregon Short Line. In 1896, also, the Utah & California Ry. Co. projected a

line to give direct communication between Salt Lake City and the coast towns of southern California. This project was described in our issue of Oct. 15, 1896, from information obtained from Mr. H. M. McCartney, who was Chief Engineer, and who (until about a year ago) was Principal Assistant Engineer on the line actually built and now completed. The plan was to utilize the Union Pacific Ry. line as far as Milford and then to build on the 125 miles of abandoned line graded in 1890 by the Union Pacific Ry. Beyond this a new line was to extend to Barstow, Cal., on the Atchison, Topeka & Santa Fe Ry. The distance from Salt Lake City to Los Angeles was about 800 miles, of which nearly 500 miles were built.

The project, however, fell through for lack of financial support and its rights were afterwards acquired by the San Pedro, Los Angeles & Salt Lake Ry., which proposed to connect the transcontinental lines at Salt Lake City with the new Pacific port of San Pedro, Cal. This line in 1901 acquired the Los Angeles Terminal Ry., having lines to the coast and inland from Los Angeles. Construction was at once commenced on a line from Los Angeles to San Bernardino. At this stage of the proceedings, however, the Oregon Short Line reasserted its rights to the old abandoned line south of Milford. As both lines were now strongly backed by rival capitalists, there was the beginning of a great fight, and at one time both parties were trying to build on the same right-of-way. The matter was taken into the courts, but after a long contest which included lawsuits, competitive construction, and personal conflicts between the construction forces of the rival lines, the result was in the main a victory for the Oregon Short Line. In 1903, however, this road sold out entirely to the other company, with the exception of its terminal line in Salt Lake City.

The San Pedro, Los Angeles & Salt Lake Ry. has now trackage rights into Salt Lake City, and two routes for over 100 miles south of that point, to Lynn Junction; one of these is the old line east of Utah Lake (132½ miles), and the other is a more favorable line, 116½ miles long, passing through Toele and west of the lake. This latter line was built in 1903, and was described in our issue of Sept. 17, 1903. The new railway is shown on the map, Fig. 1. The distance from Salt Lake City (by the short line noted above) is 620 miles to Daggett, Cal., on the Atchison, Topeka & Santa Fe Ry.; trains are run over this latter road from Daggett to San Bernardino, 93 miles, and thence over the Southern Pacific Ry. to Riverside, 11 miles. Beyond this the company has again its own lines to Los Angeles, 57½ miles, and to San Pedro, 27½ miles. The total distance between Salt Lake City and Los Angeles is about 770 miles, as compared with 1240 miles by the old route by way of Sacramento. Through communication was established in February, a temporary line of 14 miles being built to avoid heavy work near Las Vegas, Nev., and the line was opened to regular traffic in April. The present Chief Engineer is Mr. E. C. Tilton; but the greater part of the work (until the summer of 1904) was done under Mr. H. Hawgood as Chief Engineer, with Mr. H. M. McCartney, as Principal Assistant Engineer. Mr. Hawgood is at present a consulting engineer at Los Angeles, Cal.

The summit elevations are as follows: 5,971 ft. above sea level at Crestline, Nev., where the line crosses the rim of the great Salt Lake basin; 4,196 ft. at Kessler, Cal., and 3,816 ft. in the Cajon pass on the Atchison, Topeka & Santa Fe Ry. The maximum grades are 50 ft. per mile (compensated for curvature) between Los Angeles and Riverside; 52.8 ft. between Daggett and Calientes (with 18 miles of pusher grade 116 ft. to the mile and a short stretch of 80 ft. to the mile); 107 ft. per mile between Calientes and Milford; 31.7 ft. between Milford and Lynn Junction (to be reduced to 52.8 ft.); and 42 ft. per mile on the Leamington cut-off between Lynn Junction and Salt Lake City. The maximum curvature is 3° between Los Angeles and Riverside, and 5° between Daggett and Calientes. The standard track consists of 75-lb. rails of the Am. Soc. C. E. section, 33 ft. long, laid with broken joints and having four-bolt angle-bar splices. The ties are of

Fig. 1. Map of the San Pedro, Los Angeles & Salt Lake Ry.

redwood, 7 × 8 ins., 8 ft. long, with tie-plates on every tie; there are 18 ties to a rail length. The standard width of roadbed is 18 ft., as shown in the upper drawing in Fig. 2. In long cuts, or in loose material, or where much snow has to be contended with, the width is 20 ft., with wider ditches, as shown in the lower drawing in Fig 2. The side ditches are paved with cobblestones when necessary, as shown. The ballast is of stone and gravel, 8 ins. deep under the ties and filled in level with the tops of the ties to 8 ins. beyond their ends. In maintenance, however, gravel ballast is sloped off to 2 ins. below top at the ends, as shown by the dotted lines.

Between Daggett and Calientes, 300 miles, there was entirely new construction, and this is said to be the most substantial piece of new line ever built in mountain districts in this country. From Calientes south there is some very heavy work until the Nevada desert is reached beyond that again there is very heavy as Daggett. Permanent structures used almost exclusively and there are and high embankments. Between L and Riverside, steel superstructures spans of 40 ft. and over, with concrete and piers, and solid ballasted floors. numerous culverts and bridges of con 4 ft. to 30 ft. span. For minor ope 42 ins. in width, a flat top roof is used ness of the roof increasing at the cent from 9 to 21 ins. for spans of 12 to 42 require more concrete than arches, small spans this is more than offset by in labor cost. Concrete or rubble pav generally used in the openings: Near L the Santa Ana viaduct, a concrete str ft. long, and with the rails 60 ft. ove ground. It has eight arches of 86 ft. s and two approach arches of 35½ ft. This was described and illustrated in our iss of these concrete structures.

The line is single track throughout, b sidings 3,000 ft. long have been estab intervals of about five miles. There a stations at 20-mile intervals, the sup from springs or artesian wells, pumped mill pumps with 8-HP. gasoline pump serve. At each coaling station there pockets which are filled by a steam cran ing on a trestle over the storage coal handling a self-filling bucket. The main shops are at Calientes, Nev., the buildings being of brick. Owing to the undeveloped character of the country, it has been necessary to establish accommodations at several points for the maintenance forces and section gangs, and these buildings are of concrete blocks. Many of the new stations are of monolithic concrete construction.

Much work has had to be done to bring the older parts of the line up to the required standard, especially where cheapness or rapidity of construction had been the main consideration. Thus in some places the width at subgrade was only 8 or 10 ft., while the standard width is now 18 ft., as already explained. Not only had cuts and banks to be widened, but changes in alinement and profile had to be introduced. Several bridges had to be strengthened or rebuilt, and the old trestles (with 16-ft. spans) have had ballasted floors built upon them. Upon the caps were laid Oregon pine stringers 8 × 16 ins., 16 ins. c. to c., with a flooring of transverse planks, 3 × 12 ins., 14 ft. long, covered with roofing felt. The ballast is 8 ins. deep under the ties, and is filled in level with the tops of the ties; beyond their ends it is sloped down and extended to the guard timbers.

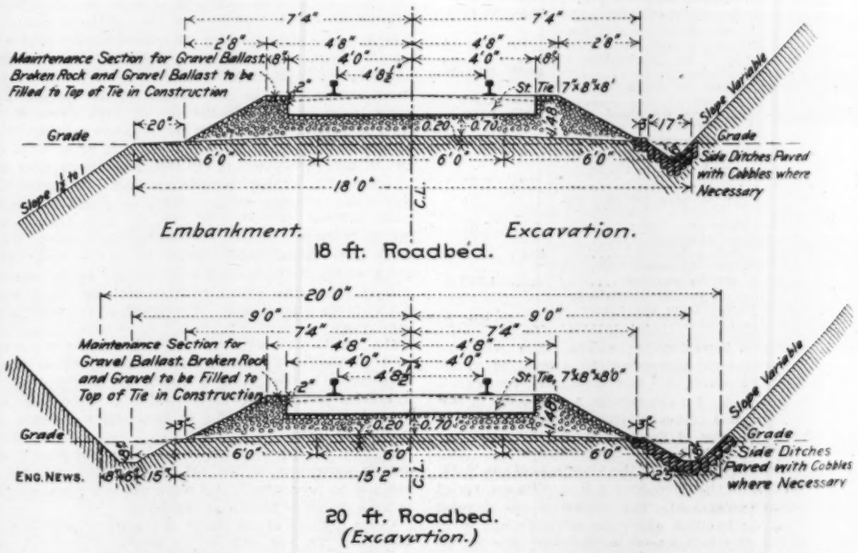

Maintenance Section for Gravel Ballast x8" Broken Rock and Gravel Ballast to be Filled to Top of Tie in Construction
Grade
Slope 1½ to 1
Slope Variable
Side Ditches Paved with Cobbles where Necessary
Embankment.
Excavation.
18 ft. Roadbed.
Maintenance Section for Gravel Ballast. Broken Rock and Gravel to be Filled to Top of Tie in Construction
ENG. NEWS.
20 ft. Roadbed.
(Excavation.)

FIG. 2. STANDARD ROAD-BED CROSS-SECTIONS; SAN PEDRO, LOS ANGELES & SALT LAKE RY.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
SAN FRANCISCO: Rialto Building
BOSTON: 170 Summer Street
ATLANTA: Austell Building
RUDOLF MOSSE, BERLIN AND HAMBURG, GERMANY

SUBSCRIPTIONS

United States and Possessions, Canada, Mexico and Cuba, One Year, $5.00.
Foreign Countries, Regular (Thick Paper) Edition, One Year, $9.00. (£1-18-0).
Foreign Countries, Thin Paper Edition (Construction News Supplement Omitted), $5.00. 21 Shillings, 25 Francs or 21 Marks.
Remit by Post-Office or Express Money Order, Draft on New York or London, or by Registered Letter. Notice of change of address should reach us one week in advance of removal. The old as well as the new address should be sent.
Receipts for Subscriptions will not be sent unless requested, the changing of the expiration number being considered sufficient. The number on the address label indicates when subscription expires, the last figure indicating the year, and the one or two preceding figures the week of that year. 52-5 means the 52d week or December 28, 1905.

ADVERTISING

"Contract": Rates furnished on application.
"For Sale": $1.50 per inch.
"Proposal": $2.40 per inch.
"Want": See pages 26 and 27.

Copy for regular, or "Contract," Advertisements should be received one week before publication; "For Sale" and "Situations Wanted" Advertisements by Tuesday, and "Proposal" and "Situations Open" Advertisements by 11 A. M. Wednesday.

Entered at the New York Post-Office as Second-Class Matter.

The specifications for the building of the Philippine railway system, some 1,200 miles in extent, were made public last week and bids are to be received until Nov. 1 next. The arrangement under which these railways are to be constructed is a peculiar one. A Government guarantee is offered not exceeding 4% per annum on not more than 95% of the actual cost of construction, for a period not exceeding 30 years, and to an amount per annum not exceeding $1,200,000. Bidders are asked to state in their bids how much less than these limits they will accept and undertake to carry out the work.

The amount named, $1,200,000, would pay 4% interest on an investment of $25,000 per mile in a system 1,200 miles in extent.

As is pretty well known, these Philippine railways cannot expect at the start to obtain a traffic that will make them paying enterprises. It is even doubtful whether a paying traffic can be secured on most of the lines for many years to come. The world moves slowly in the tropics; the conditions of life are simple, and no such rapid development of industry as has followed railway building in the United States is to be expected. The lines which can obtain a lumber or mineral traffic and those which tap regions with population enough to furnish good passenger traffic will doubtless do best; but it will be for the interest of all parties concerned that the lines be built as economically as possible.

The specifications set forth that "the construction, equipment and rolling stock shall be in every respect first-class, and, with due regard to local conditions, shall be equal in quality to the best American practice," and it is required that the railways shall be maintained and operated "according to first-class American railway standards."

There is certainly room for a difference of opinion as to what these expressions mean. First-class railway construction in the United States means a railway built with trunk line standards as to gradients, alinement and track and equipped with up-to-date high capacity rolling stock. Now such railways cannot be built and equipped in the Philippines for anything like $25,000 per mile, and no such railways are needed there. The Philippine railways should be built with a view to the economical handling of light traffic and not in conformity with first-class standards on heavy traffic railways in the United States at all. They should be built with steep grades and sharp curves wherever such alinement will save in construction cost. They should be equipped with light rolling stock to enable light permanent way to be used. They should be operated, moreover, not at all "according to first-class American standards," as the specification demands, but in the manner in which second-class or third-class branch lines are operated in the United States, where traffic is small and speeds and train service must be kept down to enable the company to pay its expenses out of its gross receipts.

Fortunately, the limitation on the capital guarantee makes it reasonably certain that the Philippine lines will be actually built with a strict regard to economy at every point, and the mistake will not be made of building a road altogether too good and too expensive for the business coming to it. The probabilities are that the engineers will have to pare very closely to bring the cost per mile of the Philippine system within the limit fixed by Congress for the Government guarantee.

There is one feature of the Philippine railway specifications which deserves some public discussion. Article V. of the specifications reads as follows:

> The term of the concessionary contract or grant shall be perpetual.

No one who follows the trend of this opposition can fail to be aware that there is a strong and rapidly increasing public sentiment against the grant of perpetual franchises. At the present time public attention is chiefly concentrated upon franchises for the use of city streets, and the principle that no such franchise should be granted in perpetuity is now generally accepted. The same principle holds, however, in the grant of concessions for general railway construction. One generation has no moral right to give away for all time to come a public franchise which may in time become very valuable and ought then to revert to the control of the generation then living.

In the United States, it is true, railway corporations have generally been given perpetual franchises. It was difficult fifty years ago to see any great value in the franchises which were freely given away to railway corporations; but these franchises have now become extremely valuable. It is difficult now to foresee the future value in the franchises for the Philippine railways, which it is now proposed to bestow on a corporation to hold for all time to come; but our own experience ought to have taught us some wisdom. Furthermore, while in this country perpetual franchises were lavishly bestowed, more careful statesmen on the continent of Europe were successful in limiting the duration of railway franchises, and, as a result, in France and Germany and other European countries the railway franchises have reverted to the government at the end of a term of years, without entailing any burden on the public or raising any such questions of the government vs. the corporations, as is now agitating this country.

We are not here advocating government ownership or operation of railways. Rather, we stand with the man, who on being asked the question, "Do you think the government ought to run the railways?" replied: "No, but I think the railways ought not to run the government."

No one can see very far into the future. No one can certainly say whether governmental policies that appear wise to-day may not reveal themselves as the depths of folly half a century hence. Ought we then to tie the hands of our wards in the Philippines for all time to come? Would it not be the course of wisdom to provide that, say fifty years hence, these franchises shall terminate?

It may be objected that such a limited franchise would make the bonds unsalable; but that objection can be met by establishing a sinking fund for the redemption of these bonds. Let a sinking fund contribution of only 6-10 of 1% per annum be made, and at the end of fifty years the bonds will all be retired and the Philippine railways will belong to the Philippine people without the raising of a dollar by taxation. This plan would have the further great advantage of overcoming the uncertainty as to the payment of these bonds. The Government, it is to be noted, does not guarantee the principal but only the interest for not more than 30 years, at a rate of not more than 4%. There is no guarantee whatever of the payment of the principal. This last uncertainty may make the floating of these bonds a very difficult matter.

Suppose, now, instead of this limited guarantee, the Government were to guarantee the 30-year annual payment of interest at the rate of 3.4%, and an annual sinking fund contribution of 0.6% per annum for 50 years. Such a bond would certainly be more attractive to investors than the bonds at present proposed, and it would place the Philippine people of the next generation in a far better position, with respect to their railway system, than the plan now adopted.

THE PROBLEM OF VENTILATING THE NEW YORK SUBWAY AND SIMILAR TUNNELS.

Since the publication of our last week's editorial on the heating of the New York Subway air by the electric current used in operating the trains, the N. Y. Rapid Transit Commission has taken action that will eventually lead to the installation of fans for ventilating the tunnel. Owing to the failure of the engineers to foresee the heating effect of the electric current, no provision was made for changing the subway air by mechanical draft, and it is announced that it will not be until next year that any relief from present conditions may be expected.

That the present conditions were not anticipated by the subway engineers is apparent, not only from the failure to provide for them, but from the actual denials that have been made as to the existence of a hotter atmosphere inside the subway than outside.

We have shown that the subway air is hotter, and we have shown why it is hotter. Our explanation of the phenomenon has not been controverted; but, as some engineers may have questioned the accuracy of our statement that only a small portion of the heat discharged into the subway passes into the earth and through the roof of the subway, we will discuss at greater length than last week the heat losses by conduction through the walls of the subway.

The experimeents of Péclet quoted in Carpenter's "Heating and Ventilating Buildings," and less fully in Kent's "Mechanical Engineer's Pocket-Book," show that a layer of stone 3 ft. thick will transmit 0.2 B. T. U. per sq. ft. per hour for each degree of difference in temperature of the opposite surfaces of the wall. Consequently if the roof of the subway were of solid stone 3 ft. thick, and if the temperature were 6° lower on the outside street surface than on the inside or ceiling of the subway, the loss of heat through the roof in 24 hours would be about as follows: 0.2 B. T. U. × 6° × 24 hrs. × 50 ft. wide × 53,000 ft. long = 76,320,000 B. T. U.

As a matter of fact, between the concrete of the roof and the concrete of the pavement there are several feet of earth. This earth acts as a heat insulator, for according to Péclet the conductivity of stones and sands are as follows for every 1° difference in temperature on opposite faces:

1 ft. layer of brick dust conducts 0.1 B. T. U. per sq. ft. per hr.
1 ft. layer of brick conducts 0.5 B. T. U. per sq. ft. per hr.
1 ft. layer of sand conducts 0.2 B. T. U. per sq. ft. per hr.
1 ft. layer of limestone conducts 1.0 B. T. U. per sq. ft. per hr.

Care must be taken not to confuse these conductivity values with the heat actually transmitted, for the heat transmitted is always less than the conductivity of the material would indicate, due to the slowness with which the heat is imparted to the surface of the wall on the inside, and to the slowness with which it is carried away on the outside by convection currents and by radiation. The conductivity varies inversely as the thickness and directly as the difference of temperature on opposite facts of the conductor.

To illustrate the effect of a sand layer between two layers of stone, let us assume that there are 2 ft. of concrete roof, then 3 ft. of sand, then 1 ft.

of concrete and stone pavement. If the temperature falls 6° uniformly from the inside of the subway to the surface of the pavement, the temperature on the under surface of the sand will be 2° higher than on the upper surface of the sand. Then the heat conducted through the 3 ft. of sand would be as follows:

0.2 B. T. U. × 2° × 24 hours × 50 ft. wide × 53,000 ft. long = 25,440,000 heat units in 24 hours.

In view of these facts it is scarcely probable that in the summer time as much as 50,000,000 heat units can be lost through the roof of the subway in 24 hours.

And now, what of the heat lost through the sides and bottom of the subway? How may we obtain an approximate idea of its amount? The problem is complicated by the question as to where the heat is to go to, for the heat is not carried off by the outside air as when it passes through the roof. Instead it penetrates into the earth and as the temperature of the earth is raised more and more the amount of heat transmitted into the earth falls off.

If the subway were surrounded by the open air, with sides and floor of the same thickness as that assumed above for the roof, the computation above made shows that the daily loss of heat from it, under the conditions assumed, would hardly exceed 10% of the heat which is daily poured into the subway by the power house generators.

Actually, however, the subway has below its floor and at its sides for a part of their height, earth at a temperature which will probably vary little from 52°, the mean annual temperature at New York City. Then if the air in the subway is at 82° there is a difference of temperature of 30° between the two.

But if heat is to pass from the subway into the earth, it must do it by gradual conduction from one layer of earth to the next and so on, and by this slow process of conduction the earth is gradually raised in temperature, being highest next the subway and rapidly falling off as we go out from it. To compute the maximum possible rate of passage of heat into the earth, let us assume that at a distance of 6 ft. from the subway floor the normal temperature of 52° is reached and is maintained without rise. This would be a drop in temperature of 30° in 6 ft., or 5° per ft. Actually, of course, the drop in temperature under the assumed conditions would extend over a much larger distance; so if we compute the heat conduction due to a gradient of 5° per ft., we shall have a loss of heat greater than can actually occur.

Let us first assume that these 6 ft. are all sand, which, according to Péclet, conducts 0.2 B. T. U. per sq. ft. per hour per foot of thickness per 1° difference in temperature. Since, according to our assumption, there is a difference of 5° in a foot, we have the following heat loss from the sides and bottom of the subway: 0.2 B. T. U. × 5° × 24 hours × 80 ft. wide × 53,000 ft. long = 101,760,000 heat units in 24 hours.

Thus we see that even under this extreme assumption of a drop of 5° per ft. of distance, there is only a nominal loss of heat through the bottom and sides of the subway. We say "nominal" because it will be remembered that as we showed last week, the heat equivalent to the electricity generated in the subway power house is 1,292,000,000 heat units per 24 hours.

It may be said, perhaps, that the use of concrete in the bottom and walls of the subway will increase the rate of heat transmission because rock or concrete or even moist earth is a better heat conductor than sand. Actually, however, the heat loss would be affected very little, because with a better heat conductor the heat would merely penetrate farther and we would have our plane at which the earth temperature of 52° is reached located perhaps 12 ft. away instead of 6 ft. away.

Thus the effect of a better conducting material under the subway floor is only to increase the ability of the subway temporarily to absorb heat, and act as a regenerator, and the effect on the amount of heat actually conducted away into the earth is very small. To put it another way: If the entire subway were thickly lined with wood or asbestos, or some other non-conductor of heat, the temperature in the subway would closely follow the hourly variations in the outside air, with the heating effect of the electric current added. As it is, the concrete surrounding the subway acts as a reservoir to equalize the variations in air temperature. It gives out heat when the air temperature falls and absorbs it when it rises. This conducting power, however, cannot in a long summer season avail permanently to carry off into the earth any large percentage of the heat which is generated in the subway.

No claim is here made, of course, that with the data available we can arrive at any exact determination of the heat loss by conduction into the earth. We believe, however, that we have assumed conditions that give the maximum possible loss by conduction. An accurate solution of the problem may be made with comparative ease by drilling into the earth or rock along the subway and embedding thermometers at varying depths, in order to determine the temperature curves.

Regarding the ventilation of the subway, it has been argued that the frequent passing of trains would serve to accelerate the natural air currents. It is our opinion, however, that the trains actually act to retard the air currents. The heated air in the subway naturally tends to move toward the highest points, that is, it will move up grade, the subway acting like a slightly inclined stove pipe leading to a flue. If while this current of air is traveling toward an exit a train moving in the opposite direction meets it, the current is broken up and retarded. But, it will be urged, half the trains will move with the air current and so offset the influence of the other half moving against it. This is not so, for the trains that move with the air current are traveling much faster than the natural air current, and therefore break it up, hurling the air in eddies to the sides. These eddies simply serve as further retardants. The trains, in a word, do not act as pistons to push the air out but rather as paddles to stir it up. Anyone acquainted with the laws governing the flow of liquids and of gases knows that the development of eddies, due to the roughness of the sides of the conduit, is the main retarding cause, and that bends or obstructions in the conduit are objectionable because they develop eddies and so consume the energy of the current in overcoming friction of its particles upon one another. If division walls, or brattices as miners call them, had been built between the tracks, the circulation of the air would have been much more perfect, for the trains would then have acted more as pistons. Frequent openings from the subway to the outer air would then be necessary in order both to minimize the effects of blasts of air at the platforms every time a train arrives and to secure the full benefit of the action of the trains as pistons.

Under the existing conditions, since it is difficult to provide openings large enough at frequent intervals, probably the only satisfactory method of ventilation will be by the use of a number of electrically driven fans. There will be no necessity of operating these fans except during the summer months, for, as proved in our last week's issue, the ventilation problem in the subway is solely a problem of keeping the temperature down. It is obvious, as the New York "Tribune" has said, in commenting upon our editorial, that a temperature in the subway, several degrees higher than the outside air, is not only uncomfortable but actually dangerous to the health of persons who are not in good physical condition. This is borne out by the number of cases of fainting that have already occurred in the subway, although the temperature is now considerably lower than it is likely to become a few weeks later.

There may be days this summer when the temperature of the outside air in the streets will approach 100° F. If then this extremely hot air passes into the subway and receives an additional 5° or 6°, as it assuredly will, the limit of endurance will be reached for many passengers. There is only one source of relief and that is the fanning that a person receives when trains are moving rapidly; but anyone who has been caught in the recent blockades in the subway can testify to the extreme discomfort, due to the high te[mpera]ture when the train is standing still.

The assertion has been frequently [made] that the oppressiveness of the subway air [is due to] the presence of a large percentage of [moist]ure. This is another fallacy. The fact is th[at] even if the subway air does contain a little m[ore] moisture than the surface air it is less noti[ceable] because the air in the subway is hotter a[nd there]fore drier than the surface air.

In the winter months, the subway is a pleasant place to be in, for the very reason that now so unpleasant. The winter air is heated several degrees above normal, and, even were there no heaters in the cars, the subway would be quite comfortable, except on the coldest days. Not only would it be needless to run fans in winter months, but it would be a source of actual discomfort to the passengers.

That the subway is bound to be warmer both in winter and in summer than the outdoor air will be conceded, we believe, by any engineer who carefully follows the above discussion. Forced ventilation by fans in summer will probably be able to keep down this temperature difference to a point which will make the subway usable, although during a very hot wave there are pretty sure to be numerous heat prostrations there.

The only chance of making the subway really cool in summer will be by forcing artificially cooled air into it. There is a possibility that this might be made commercially feasible by the use of batteries of air coolers, with water from the rivers as the cooling medium; but we see no other possibility in this direction, as the cost of any refrigerating process to overcome the immense amount of heat due to the electric energy, would make it out of the question.

LETTERS TO THE EDITOR.

A Suggestion for Turning Hollow Reinforced Concrete Dams Into Power Houses.

Sir: Referring to the very ingenious Schuylerville hollow reinforced concrete dam described and illustrated in your issue of April 27, 1905, it occurred to me at the time I read the article that the method of construction might be made to lend itself to the installation of turbines and electrical generators within the dam itself. The large cost of developing many water powers might thus be considerably reduced.

It would seem that wherever there is sufficient head at the dam, such an arrangement would be entirely feasible. The head race, as well as a separate power house, could thus be done away with, the penstocks being built into the deck, and openings for the water leaving the turbines could be provided in the base of the dam.

Yours truly, Howard W. Starr.

18 Union St., Schenectady, N. Y., June 11, 1905.

Concerning the Calculation of Column and Girder Systems.

Sir: With respect to the inquiry in your issue of May 11 regarding eccentric loading of columns, let me submit the following remarks:

By making provision, in a system of columns and girders, that the girder reactions are transmitted vertically and no bending moment of appreciable amount is imparted through the connections to the columns (as for instance by means of shelf or expansion hole construction), all levers and forces are determined and the problem is simple.

In case of very heavy loads and long spans, or with a view to resist wind pressure, a solidly riveted system of continuous girders and columns is frequently to be recommended and will liberally pay for the very careful computations required in this case. It must be acknowledged, however, that in many such cases equal economy in material could be obtained by substituting a suitable cantilever system, which allows of a simple solution, all levers being known.

The writer has exhibited the method of calculating continuous systems (of girders and columns riveted together) in a pamphlet "The Theory of Elasticity Applied to a System of Continuous Girders and Columns," and has had repeated occasion to apply this method in actual design.

Very respectfully,

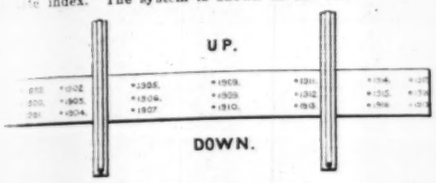
Charles R. Steiner.

Chamber of Commerce Bldg., Denver, Colo., June 12, 1905.

Method Adopted for Marking Railway Ties in Queensland.

Sir: Referring to the Committee Reports of the American Railway Engineering and Maintenance of Way Association, as dealt with in an article in your paper of March 23, 1905, p. 321, and especially with regard to the

"Marking Ties," I have the honor to inform you in this State we have for the last seven years been e habit of marking all new ties put in the road with e index. The system is shown in the cut.



An auger hole is bored right through the sleeper in e of 21 positions according to the year, as shown in the accompanying diagram. It is believed that this hole, at all events with our hard woods in Australia, will do no harm to the sleeper and will remain there as long as the sleeper does. Each hole represents one year beginning at 1890 and ending at 1919, and according to the year in which the sleeper is laid the position of the hole bored is varied from year to year. If the sleepers are bored by machinery the date hole can be bored at the same time, or if the holes for the spikes are hand bored, the date hole can be conveniently bored at the same time.

For some little time we tried galvanized iron date-nails, but found they would not drive in our hardwood without boring a hole for them, which made it too expensive; in any case, it was doubtful whether date nails would last as well as the holes.

Although we have only had an experience of seven years, I am well satisfied with the results of our system.

I am, sir, yours faithfully,

W. Pagan, Chief Engineer, Queensland Railways.

Brisbane, Queensland, May 9, 1905.

The Connecticut Avenue Concrete Arch Bridge at Washington, D. C.

Sir: In reading the description of the Connecticut Avenue Bridge published in Engineering News of June 1, my attention was attracted to the following statement:

> The site of the bridge being conspicuous topographically, as indicated, great effort was warranted to have it comport in proportions, type and style with the dignity of the thoroughfare of which it was a part. It was for this reason that competitive plans were secured, and that the massive full centered masonry and design submitted by Mr. Morison was adopted, instead of the lighter reinforced concrete and steel arches of other competitors.

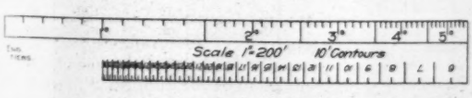
The following comments occur to me. Reinforced concrete arches can also be made full centered, and with a saving of at least 50% in materials as compared with plain concrete arches. Moreover, the visible parts of both main and secondary arches in reinforced concrete can be made of the same proportions, type and style as a plain concrete arch by using concrete blocks on the faces. By using reinforced instead of plain concrete, the volume of concrete above the springing line of the main arches can be reduced at least 50%. It is stated in the description that about 50,000 cu. yds. will be necessary for the construction of the bridge, and at least half of this volume lies above the springing line. This portion reduced by 50% is 12,500 cu. yds., and 12,500 cu. yds. saved at a cost of $10 per cu. yd. makes a saving of $125,000. Taking off $25,000 for reinforcing steel and extra labor, there remains a net saving of $100,000. In making this calculation, no allowance has been made on account of the reduction in the size of foundations, owing to the smaller weight of the reinforced concrete superstructure. Very truly yours,

Joseph Babiczky.

Guardian Trust Building, Kansas City, Mo., June 8, 1905.

Recording and Plotting Contours.

Sir: As Solomon says: "Verily, there is nothing new under the sun." Your correspondent, Loc. Engr., on page 579 of your issue for June 1, 1905, fails to understand the field method of taking contours as mentioned by Mr. Jno. E. Walker, on page 447 of your issue for April 27, 1905. Mr. Walker uses an ordinary hand level and a graduated rod, and determines rise or fall in feet, where the slope changes, while Loc. Engr. takes his slopes with a clinometer and uses degrees, which is quite a different matter.



Scale for Plotting Contours.

In this connection Mr. Walker uses the word "transversely" (line 12) when he means to say "where the slopes change longitudinally," or, as it is usually termed, at breaks of ground.

It is doubtful if Loc. Engr.'s method of taking slopes with a clinometer is very much practised in these modern days. The writer recalls, in the dim past when the method was very much in vogue among the "old timers," using a home made slope board graduated to degrees, with a piece of string and a bullet for a pendulum. This slope board was generally 10 ft. long, and in the hand of an agile and lively operator a good deal of ground could be covered in a day.

For the purpose of plotting the contours, use a graduated scale, on the edge of which the distances corresponding to a 10-ft. rise are laid off for each degree of slope. This is readily done by taking the co-tangents and moving the decimal point one figure to the right. This scale is very much simpler and easier to use than the 26 cards which Loc. Engr. mentions.

As he evidently considers speed of plotting, rather than accuracy, the great desideratum, I think the device mentioned above will keep him "humping" to keep up.

Yours truly, Engineer.

New York, June 14, 1905.

An Early Design for a Concrete Substructure for Railway Track.

Sir: I have read your editorial in the issue of June 8th on "What will be the Future Railway Track for Heavy Traffic?" with a great deal of interest.

Having made an investigation of the methods of utilizing blast furnace slag in Europe in 1879, and subsequently having conducted a series of experiments on my own account, I became impressed with the value of granulated slag as a material for the matrix of concrete, when used with either lime or cement or both.

In 1887 I suggested to the late William P. Shinn (Pres. Am. Soc. C. E., 1890) that if a concrete permanent way for railroads were desirable, granulated slag presented decided advantages over ordinary sand for such purpose, and that for use on the Pennsylvania R. R., where it was produced in large quantities, it would have the advantage of cheapness.

In 1891 a paper was read at the Chattanooga meeting of the American Society on the subject of continuous bearing for rails as practiced in Germany, and on Mr. Shinn's return home he requested me to restate the advantages of granulated slag, and made estimates of the cost of such permanent way.

The estimates provided for the laying of a concrete roadbed the full width of present roadbed, using a portion of the broken stone now in place for the aggregate, and granulated furnace slag with lime and Portland cement for the matrix.

My recollection is that he estimated the cost at $6,000 per mile, which, he said, was the cost of the original broken stone roadbed on this railroad.

Previous to his death, May 2, 1892, he had arranged that I should visit Europe for the purpose of securing all the data in connection with, and photographs of, all important structures in which that material had been used, with a view to the presentation of a paper at the next summer meeting of the Society. While he did not anticipate a favorable reception of the idea by the engineering profession, he had hoped to be able to interest Mr. Frank Thomson, President of the Pennsylvania Railroad, to the extent of putting in a short piece of track for experimental purposes. Mr. Shinn's estimates on the operation of such a track showed a saving for maintenance of way, motive power and that portion of maintenance of cars due to track mileage of more than 25%, to which also would be added the advantages in safety, speed and comfort which could not be accurately stated in money value. Yours truly,

Jos. A. Shinn.

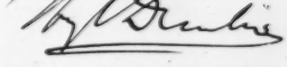
5817 Alder St., Pittsburg, Pa., June 14, 1905.

HENRY STURGIS DRINKER; THE NEW PRESIDENT OF LEHIGH UNIVERSITY.

Engineers in all branches of the profession will be interested to learn that the author of that monumental treatise, Drinker's "Tunnelling," has just been elected president of Lehigh University. Doubtless many engineers, particularly of the younger generation, supposed that Mr. Drinker had retired from active practice years ago. The latter supposition is correct in so far as engineering is concerned, for after a few years of railway engineering work and the publication of a book which has given the author a world-wide reputation, Mr. Drinker entered the legal profession, continuing, however, in the railway field. Mr. Drinker was unanimously elected to the presidency of Lehigh on June 14, and will fill the place made vacant last November by the death of Dr. Thomas M. Drown.

Mr. Drinker was born in Hong Kong, China, in 1850, and graduated as a mining engineer from Lehigh University in 1871. After serving for one year as Colliery Clerk with the Lehigh Valley Coal Co., he entered the service of the Lehigh Valley Railroad in the engineering department. From 1872 to 1875 he was resident engineer of the Musconetcong Tunnel on the New Jersey extension of that road, and afterwards he served in the main engineering offices of the company. He then studied law, being admitted to the bar in 1878. Later he became the General Solicitor for the Lehigh Valley Railroad & Coal Co., which position he has held through six administrations. He resides at Haverford, Pa., a suburb of Philadelphia, but will remove to South Bethlehem next fall.

In February, 1875, Mr. Drinker read a paper on the Musconetcong Tunnel before the American Institute of Mining Engineers. After publication in the Transactions of that body, the paper was widely reprinted in this country and in Europe. At that time the American literature on tunnelling was meager and fragmentary; the British had Simm's work, published some forty years ago and then recently revised by Clarke, but that did not fill the needs of the day; there was something in Italian, more in French, and much, compared with the other languages, in German. Mr. Drinker undertook the great task of producng a treatise on tunnelling, international in the range of information which it contained. Accordingly he prepared circulars in several languages and sent them broadcast over the world.



The result is well known. Had the author continued in the engineering field instead of entering the legal profession doubtless he would have built up a tunnel practice unequaled by any other engineer of his time. Whether his income would have been commensurate with his reputation and whether his earnings and general comforts in life would have compared favorably with what he has experienced as a legal practitioner and a general solicitor for an important railroad corporation, is a matter beyond our ken.

Lehigh University is to be congratulated on its choice of a president who has had engineering experience, has been eminently successful as a technical author and who has for many years occupied an important position in railway management.

REINFORCED CONCRETE SLAB ROOFING FOR A SMALL WAREHOUSE.

The accompanying illustrations show a roof covering of reinforced concrete slabs employed in constructing a warehouse for the Chittenden Power Co., of West Rutland, Vt. As will be seen, the construction consists of cast reinforced slabs, 9½ × 4 ft. × 3½ ins. thick, fastened directly to steel roof trusses spaced 9 ft. 8 ins. apart on centers. The construction is shown by Fig. 1. The slabs are laid with their long sides parallel

with the ridge and their ends resting on the double angle top chords of the roof trusses, so that a 2-in. space intervenes between the ends of adjacent slabs, as shown by the section A B in Fig. 1. As the slabs are constructed with the reinforcement projecting 2 ins. clear of the concrete at the ends, the projecting edges of reinforcement are lapped across the open space. Flattened ½-in. rods are driven through the lapped reinforcement and between the two chord angles, and their tops and bottoms are bent over so as to clamp the reinforcement to the chord. After the clamps are placed the space between the ends of slabs is filled with concrete, and the roof is ready for the waterproofing.

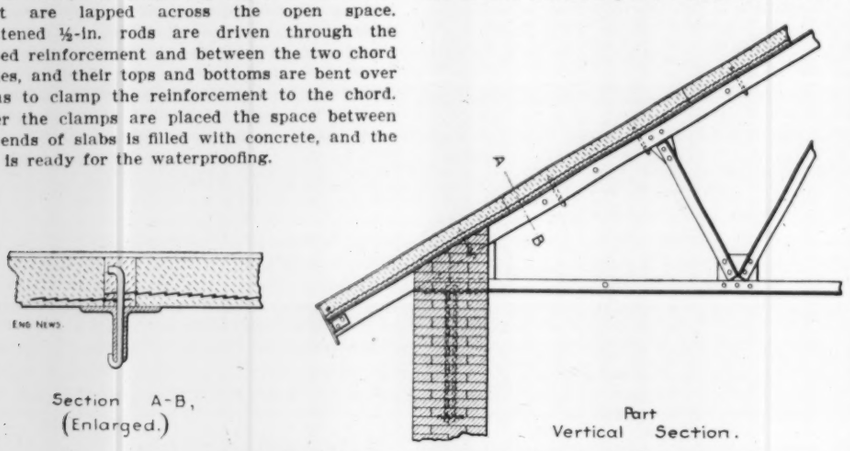


FIG. 1. DETAILS OF REINFORCED CONCRETE SLAB ROOFING FOR WAREHOUSE OF CHITTENDEN POWER CO., WEST RUTLAND, VT.

The method of casting the slabs is shown by Fig. 2. Substantial wooden forms, with the end boards in two parts to allow the reinforcement to project outside of the forms, are set horizontally on suitable mud sills. A ½-in. layer of neat cement mortar is spread on the bottom of the form or mold, and the reinforcement, which is expanded metal, is laid on this mortar bed. The cement is then dumped into the forms from wheelbarrows, and is thoroughly tamped and roughly troweled on its top surface. The mixture used is 1-2-3½ in. stone concrete. The slabs are allowed to set one week and are then removed from the forms and placed on the roof.

The engineers and contractors for this roof work are J. G. White & Co., of New York City, and we are indebted to them for the information from which this description has been prepared.

ANNUAL CONVENTION OF THE AMERICAN RAILWAY MASTER MECHANICS ASSOCIATION.

The thirty-eighth annual convention of the American Railway Master Mechanics Association was held at Manhattan Beach, New York, on June 14, 15 and 16. As will be observed by those who follow this report through, the program was a long one—the technical proceedings alone comprising the presentation and discussion of eleven special committee reports, two individual papers and six special topics—but by prompt attendance and close attention to the work in hand it was carried through without neglecting any essential feature. As a rule, the committee reports, while showing faithful work, did not mark a very high plane of technical investigation; the individual papers were much more able and in each case received active discussion by the members present. The exhibit of railway appliances, which is always a notable one at the conventions of this Association, was even better than usual, and the customary lavish entertainment was provided by the visiting exhibitors.

In the report of the proceedings which follows, liberty has been taken with the chronological order of the work so that all the routine business and all the topical discussions may be presented in one place and not scattered through the proceedings as they actually were. The papers and the special committee reports are presented in the order in which they were considered and without regard to the session for which they were scheduled.

BUSINESS PROCEEDINGS.

In his opening address to the members, President P. H. Peck (Chic. & Wn. Ind.) was very brief. In addition to outlining the work before the convention in the shape of special reports and papers, he urged the adoption of more standards, and suggested specifically the establishment of standard designs for cylinders; piston heads and rods; packing rings; cross-heads; driving boxes; shoes and wedges; eccentrics and straps, and steam chests and covers. The Secretary's report showed the membership of the Association to be 793; that the several scholarships of the Association were being utilized, and that the change in the constitution providing for representative membership had been well received by the railways, some 30 of which had appointed such members. The report of the Treasurer showed a balance on hand of $15,535. The dues for the coming year were made $5 by vote of the convention. The appointment of temporary committees to audit the accounts and on Correspondence and Resolutions and on Obituaries, and the consideration of invitations and other communications completed the routine business with the exception of the election of officers which resulted as follows. President H. F. Ball, Superintendent of Motive Power, Lake Shore & Michigan Southern Ry., Cleveland, O.; First Vice-President, J. F. Deems, General Superintendent of Motive Power, Vanderbilt lines, New York City; Second Vice-President, Mr. McIntosh, Superintendent of Motive Power, Central R. R. of New Jersey, Jersey City, N. J.; Third Vice-President, H. H. Vaughan, Superintendent of Motive Power, Canadian Pacific Ry., Montreal, Canada; Treasurer, Angus Sinclair, 136 Liberty St., New York City.

TECHNICAL REPORTS AND PAPERS.—In introducing the technical proceedings, comment is deserved on the excellent character of the discussion. In most cases this discussion was terse and to the point, but even then it was so ample that only a very brief abstract of each member's remarks can find space here.

LOADING LOCOMOTIVES.—The quotation summarizes quite clearly the of the committee:

> The important factor underlying the proper locomotives is the length of time which may hauling a train over a controlling section of this controlling section may be an opposing stretch of single track in an otherwise multiple distance between sidings, etc. As the time longer, or shorter, so may the loading of the be heavier, or lighter. The length of time ha fixed, the next two important factors are the the locomotive and the resistance of the train.
>
> The power of the locomotive may be calcu a reasonable degree of accuracy, but without the peculiar conditions of each case it will sible to say what allowance should be made fo dition of the locomotives, for the water, the fu the almost innumerable items, some of which tention in each locality.
>
> The train resistance contains a greater nu variables than enter into the calculations of of the locomotive; the number of cars and the tion, track conditions, atmospheric conditions and When the rating is very accurate the total should be ascertained by more accurate means tha prevailing at the present time in many places.

The discussion of this report was opened by Mr. W. G. Wallace (D., M. & N.), who considered that the rating should be governed by the amount of traffic and the importance of the trains, and should be determined by the operating officer and the representative of the motive power department so as to enable all engines in service to produce the highest revenue. As a fixed rating was not applicable to all conditions, the rating should be left to the officers of the division on which the locomotives were employed. Mr. H. H. Vaughan (C. P.) thought that the heavier the locomotives were loaded, so long as the train could be handled at fairly economical speeds of 10 to 15 miles per hour, the better it was. Mr. F. H. Clark (C., B. & Q.) agreed with Mr. Vaughan that the economical loading of locomotives lay somewhere about the load with which they could make a speed of 10 to 15 miles per hour.

LOCOMOTIVE TESTS AT ST. LOUIS.—The committee on this subject reported that the work of compiling the figures of the tests had barely been completed, and until the figures had been made public by the Pennsylvania R. R. they could not be reported upon. The committee stood ready to report in detail at the next convention. By vote of the members the committee was ordered continued to report next year.

SUPERHEATERS FOR LOCOMOTIVES.—This individual paper by Mr. H. H. Vaughan is printed together with the discussion which followed it, in another column of this issue.

LOCOMOTIVE FORGINGS.—The report recommended standard specifications for adoption by the Association. These specifications are printed in full in another column of this issue. There was no discussion.

SHRINKAGE ALLOWANCE FOR TIRES.—This committee was appointed to consider whether the present shrinkage allowance of 1-80 in. per foot was sufficient for large diameter wheels with cast steel centers. The committee sought information by means of a circular of

FIG. 2. VIEW SHOWING METHOD OF CASTING REINFORCED CONCRETE ROOFING SLABS.

[illegible]y, and as the result of the answers received [illegible]rted as follows:

[illegible]r carefully considering the subject and the number [illegible]omotives represented by the different roads which [illegible] answered the circular, your committee is of the [illegible]n that a change in shrinkage allowance for large-[illegible]ter wheel centers would be advisable.

[illegible] would recommend that the present shrinkage of [illegible]n. per foot in diameter be retained for all centers [illegible]st iron and cast steel less than 66 ins. diameter, [illegible]-60 in. per foot in diameter be used for cast-steel [illegible] cast-iron centers 66 ins. and over in diameter.

[illegible]m the replies received, correspondence and discus-[illegible] among the members of the committee, the consensus [illegible]pinion is that the design of wheel centers, especially [illegible] of cast steel and of large diameter, has much to do [illegible] the question of loose tires. Your committee, there-[illegible], recommends that this question, including sugges-[illegible]s for preferred sections of spokes and rims, numbers [illegible] spokes, etc., would bear further investigation, which [illegible]ight be desirable to refer to another committee.

[illegible]e important point to be remembered in considering [illegible] question of cores vs. solid rims is that each pound [illegible]f metal cut out of the rim opposite the counterbalance [illegible]nts the center to be reduced two pounds, as the [illegible]mount of metal has to be accounted for in the counter-[illegible]lance. It is therefore probable that due consideration [illegible]was not given to this side of the question in the replies [illegible]ceived.

That tires are rolled out or stretched when worn to, say, about 2¼ ins. in thickness has been confirmed by very careful measurements made of the tires after removal. The consensus of opinions and replies indicates that most of the difficulty experienced from loose tires occurs when they are worn to thicknesses varying from 1⅞ ins. to 2¼ ins.

Loose tires are also caused by light cast-steel centers of insufficient section of spokes and rims to resist the shrinkage of the tire. This may also be occasioned by the distance between hubs being too great, requiring the spokes to be dished. In such cases when the tire is shrunk on, the wheel center will be dished. The suggested standard distance between hubs on locomotives for standard gage is 55 ins. This allows the use of straight spokes.

Broken tires are often caused by bad shimming when tires become loose and shims and liners are used, which only partially cover the circumference of wheel center and do not butt against one another, but leave spaces several inches in length. The tire is unsupported at these points and repeated transverse bending stresses are caused at each revolution of the wheel. Broken tires are again caused by too much shrinkage caused by improper gaging, and too much emphasis can not be placed upon the necessity of providing a first-class system of gages, both for boring tires and turning off wheel centers. These should be referred to master gages from time to time, to insure their accuracy.

A very large number of passenger locomotives in use have driving-wheel centers 72 ins. in diameter. The Master Mechanics' standards are 70 ins., 74 ins., etc., and we would recommend including 72 ins. diameter among the number of standard sizes. The use of this size at the present time would warrant its recognition.

Your committee is of the opinion that the question of limit of thickness of tires for different purposes should be fully investigated and recommendations which would lead to standard limitations based on diameters, service and weight per wheel be recommended.

The Pennsylvania Railroad has used 1-64 in. per foot in diameter for a great many years for all sizes of wheel centers, both cast iron and steel.

The suggestions of the committee are summarized as follows:

Shrinkage 1-80 in. per foot in diameter for cast-iron and cast-steel centers less than 66 ins. in diameter.

Shrinkage of 1-60 in. per foot in diameter for centers 66 in. and over in diameter.

Minimum thickness of tires should be established, due consideration being given to the diameter, service and weight per wheel.

Tire and wheel gages should be of good design, heavy enough to resist bending and subject to frequent inspection to insure accuracy.

Seventy-two inches diameter of wheel center should be included in standard sizes.

Wheel center rims should preferably be uncut, but, if cut, slots should be machined out and closed with solid cast-iron liners driven in. No lead or white metal to be used.

This report aroused a surprising amount of discussion. Mr. F. F. Gaines (L. V.), saw no reason why the amount of shrinkage allowance should differ for wheels of different diameter. He thought that a greater shrinkage allowance was necessary for steel centers than for iron centers. Mr. G. W. West (N. Y., O. & W.) agreed with Mr. Gaines that greater shrinkage allowance was necessary for steel centers, and practically the same opinion was expressed by Mr. A. E. Manchester (C., M. & St. P.), Mr. Wm. McIntosh (C. R. R. of N. J.), Mr. H. V. Rosing (Ill. Cent.), Mr. A. E. Mitchell (L. V.), Mr. E. A. Miller (N. Y., C. & St. L.), Mr. W. G. Wenzell (Wis. Cent.) and others. These same gentlemen were all agreed also that the present design of cast steel wheel center was too light. As the result of the discussion, the committee was ordered continued, with instructions to consider the whole question of wheel center design and to report results.

Locomotive Terminals.—This report presented two places for locomotive terminals and presented the merits and demerits of each as a "machine for handling engines." The discussion which followed was quite long and consisted chiefly of descriptions in outline of the terminals of the roads represented by the speakers. Only a few general features will be quoted. Mr. H. H. Vaughan (C. P.) stated that recent practice on the Canadian Pacific Railway was to heat roundhouses by direct steam system. Mr. Geo. W. West, (N. Y., O. & W.) had recently built a roundhouse heated by the Sturtevant hot-air system.

TECHNICAL EDUCATION OF RAILWAY EMPLOYERS.—This individual paper, by Mr. G. M. Bosford, we postpone to our next issue.

Water Softening.—The committee on this subject reported that tests were still in progress and asked to be continued another year. In the brief discussion, Mr. A. E. Manchester (C., M. & St. P.), and Mr. E. W. Pratt (C. & N. W.), called attention to the alkali waters of the plains and urged that they be given special study. The committee was ordered continued by vote of the convention.

Time Service of Locomotives.—The committee was of the opinion that the greatest opportunity for increasing the mileage of engines lies in reducing delays in service and not in rushing them through the roundhouses. It urged that railways should endeavor to prove this for themselves by keeping for a time accurate time records of locomotives in service. The report was received.

Shop Layouts.—This report consisted largely of an abstract of a series of 15 articles on railway shops, published by Mr. R. H. Soule in the "American Engineer." The principal discussion was by Mr. F. F. Gaines (P. & R.), and was a general criticism of longitudinal shops and an argument in favor of transverse shops.

Locomotive Front Ends.—This committee was appointed last year to continue the tests on locomotive front end arrangements. It reported that its work so far had consisted in raising money to pay for the tests and that it had obtained by subscription the sum of $5,065. It was now preparing to begin the testing operations at once. There was no discussion.

TOPICAL DISCUSSIONS.

The following topics for discussion were taken up at different times during the three sessions, and have been grouped here:

The Mechanical Stoker.—The typical discussion on the Mechanical Stoker was opened by Mr. William Garstang as follows:

Ten years ago most of us thought the maximum size of locomotives had been reached, when a spurt followed and the locomotives grew rapidly. Has the limit yet been reached? The engine having grown to such proportions in the past ten years, it is pertinent to ask, has the fireman also grown in that time? Experience says "No." An engine with 50 sq. ft. of grate surface, burning 200 lbs. per hour per square foot, will consume 5 tons per hour, and if you get a fireman with sufficient physicial endurance to handle 5 tons of coal per hour on an engine scheduled 45 (or 50) miles per hour, as they are to-day, he will very likely fall below the requisite in brain power, and, of course, be an inefficient fireman. This we all know from experience. So it seems our engines have passed the limit of human endurance in the matter of efficient firing.

A young man thinks he would like to fire a locomotive; he makes application for the job; he goes with the foreman to look over an engine, and the enormous size of the boiler fills him with dismay, and he goes into some other business. This means that the work on the big engines is more of brawn than of brain. Some will say "That is all you need for a fireman." But where are our engineers to come from? Surely they must be men of "head," now more than ever, when speeds are high and trains are heavy. This employment of "coal heavers" for the left hand side of the engine will surely be felt before long on the right hand side, when promotions must be made.

They say "necessity is the mother of invention." It seems to have been so in this case. I presume some one, seeing farther ahead than most of us, thought, "Why won't an automatic stoker work as well on a locomotive as on a stationary boiler?" To think was to act, and we now have a practical mechanical fireman that is going to revolutionize the grade of men who enter the firing service and eventually become engineer. Instead of the "horny handed son of toil," with a back like a horse, who must work like a coal heaver for ten or twelve hours continuously, we will have a set of men of greater intelligence—men whose heads will guide the stoker and control it—men who will not sit idly in the engine cab by any means, but who, though busy, will not be continually "frizzled" back of the open fire door, with their eyes blinded so that signals cannot be properly interpreted; but who, through intelligent operation of the stoker and careful watchfulness of the track and signals, and who coming in from a trip are not so tired out that they cannot study the rules and regulations and prepare themselves for advancement, will make a high grade of locomotive engineers when advanced to that position, and which will gradually mean a continuous elevation of both the men and the service.

Now, as to the stoker in actual service. It has been four years since the first mechanical stoker was tested on a Big Four engine. About six months ago we installed a mechanical stoker known as the "Victor," and same as the one on exhibition at the convention, on seven of the largest passenger engines on our system. Four of these engines have wide fire boxes and three have the long, narrow fire box. Both styles of fire box have been fired satisfactorily by the Victor mechanical stoker. From advices we receive from the division officers, we can safely say there is a noticeable saving in the amount of coal consumed per car and engine mile when operated with the stoker in comparison with hand firing, but at this time we are not prepared to state the exact per cent. of such saving. The same advices indicate a reduction of boiler work, on flues, staybolts and fire box seams, which, in our opinion, is due to the fact that we are enabled to carry a lighter, cleaner and more uniform fire, as well as uniform boiler pressure.

During the six months in which these stokers have been in service the cost of their maintenance has been very light. The principal cost of maintenance is largely due to improper lubrication. What few failures we have had with the stoker are due to the same cause.

In conclusion, I will say it is my opinion the mechanical stoker for locomotives has come to stay.

First, because it is practical and efficient.

Second, we believe, by the adoption of the mechanical stoker the railway companies will be enabled to use a cheaper grade of coal than can be used in hand firing, resulting in a great reduction in their fuel bills.

Third, it will relieve the fireman of some of his most arduous labor and give him greater opportunity to observe signals while on duty, and he will arrive at the end of his run in condition to improve his chances by study for promotion to the position of engineer.

Mr. George L. Fowler—I had the pleasure a few weeks ago of taking a trip over Mr. Garstang's road on an engine equipped with one of the stokers of which he speaks. I have been very much interested in the matter for a number of years, and I was more than surprised at the results which were obtained on that line. He left Cincinnati on a train consisting of eight cars, weighing approximately 440 tons, hauled by an Atlantic type engine. The stoker was in use all the way. The coal was a very fine grade of West Virginia coal from the Kanawha mines. It was kept well wetted down, and the work that the fireman did as far as coal shoveling was concerned was merely dumping the coal into the hopper, and the stoker did the rest. After leaving Cincinnati about 19 miles there is a very heavy grade, 13 miles long and rising at the rate of about 55 ft. to the mile. We went up that grade in, I think, 25 or 30 minutes, with the pointer glued at about 190 to 195 lbs.; and the fireman apparently taking it very easy. He would fill up the hopper and then hang around and fill it up again. He did not show any signs of fatigue. He did not perspire in the slightest and had ample time to stand in the gangway and get cool. The engine held its speed and steamed right up the grade.

The stoker is not yet, I think, in its finished condition; there are many little things about it which can be improved. It is by no means a smoke consumer. The smoke is black from start to finish, there is no clearing up of it, but you can count the strokes of the stoker by the appearance of the stack. When the plunger draws back it opens a space about five or six inches in diameter and allows an inrush of fresh air down underneath the deflector plate. When that air comes in the smoke lightens up, and as the opening closes on the forward stroke of the plunger, shutting off the supply of air, the smoke becomes thicker and is very black, just as black as any smoke coming out of any stack would be. That means, of course, that some change in the admission of air above the fire may be an advantage.

Mr. W. E. Symonds (K. C. So.)—I think this is a subject which should be taken up in regular committee work. The roads buying large power, I think, are contemplating the use of a mechanical device for firing their engines, and it seems as reasonable to suppose that it will displace the firemen on these large engines as that the injectors of to-day displace the pumps used years ago.

Mr. W. S. Morris—I heartily concur in Mr. Symonds' remarks in suggesting that this subject be assigned to a special committee, which committee shall conduct tests and experiments and make an exhaustive report.

I think the stoker has come to stay. I think in its present condition it is a wonderful addition to the service. We do not have the firemen to-day that we did ten years ago, even. There is no attraction for a young man to accept a position as fireman, as Mr. Garstand states. He comes up to the registering station and sizes up the engine, and if he is pretty gritty about one out of five will go part way, and that is about the end of it. The brakeman's position is more attractive, and we do find among the brakemen, particularly among the new men employed, a higher degree of intelligence, because the work is not so exhausting. The firemen of to-day do not take the positions though choice; it is

largely from necessity. The stoker even in its present state relieves to a great extent the work of the individual in that position.

Four or five years ago, when this stoker was first introduced, I had some experience with it and personally made several trips with the stoker on an engine having an 11-foot fire box, where it was not possible to keep the steam up to the popping point when the engine was fired by hand. The application of the stoker on the same engine kept the engine steaming to the point of blowing off up an 80-foot grade, with full tonnage all the time.

Mr. Fowler states that there is a good deal of smoke. Now, while there may be some, I believe the constant introduction of coal in proper quantities had a great deal of effect on the amount of smoke emitted from the locomotive at the time I made the trip up the mountain on the C. & O. Road.

Mr. Angus Sinclair—I have had considerable experience with the automatic stoker in watching its operation while riding on engines equipped with it, and I wish to testify to the favorable impression which I have received of it. There is no new device which comes into service but what there will be some criticism or other of it at first. I have gone through the experience of helping to introduce a great many things that are held as regular appliances for locomotive service nowadays, and in every case that I remember there was more or less difficulty. My impression of the locomotive stoker is that it is certainly as efficient now as the injector was when we got to first using it, just as efficient as the balance valve was when we got it first, and as was the case with many other things that might be mentioned if one could think of them all.

I feel certain that it is merely a matter of time when all heavy locomotives, not only in this country, but everywhere else, when it becomes beyond the capacity of a human being to fire them, will be equipped with the mechanical stoker. You see it is getting to be nowadays that the capacity of the locomotive is the capacity of the fireman to maintain steam. When that capacity has been reached it is only the part of engineering to get something better, something that you put power on instead of human muscle. I feel sure that several stokers already invented are capable of taking that place, and that automatic stokers will be as regular an appliance of locomotives ten years hence as the injector is to-day.

Mr. C. A. Seley (C., R. I. & P.)—There is one point that might be mentioned in this connection, that, as the development of the stoker is not yet complete and it will be some time before the railroads can avail themselves of the perfected automatic stoker, we can ameliorate the work of the fireman considerably by handling his door for him, instead of putting that labor on his hands. We have in use on the Rock Island a very large number of automatic door openers, which enable the fireman to keep both hands on the shovel. The opening and closing of the door is no small part of the labor of firing, and it is a fact that our heavy doors are not closed oftentimes as they should be after the coal is put in.

Mr. J. F. Walsh (C. & O.)—There is much stress being put on the fact that the coal has to be shoveled into the stoker magazine. That is not necessarily so. We have operated a stoker with a 60-car train for 60 miles without the fireman handling a shovelful of coal, by raising the floor of the tender so as to give the coal a slight pitch into the hopper itself. In another instance we attach a scoop in such a way as to permit it to run back into the coal pile and give it an eccentric motion by attaching it to one of the tender truck axles and work the coal forward into the magazine.

ARE SELF-CLEANING FRONT ENDS SATISFACTORY?—Mr. E. W. Pratt, Chicago & Northwestern, opened the discussion as follows:

On the Chicago & Northwestern Railway we think the self-cleaning front end is satisfactory. All our larger classes of power are so equipped, and many locomotives with cylinders as small as 17 and 18 ins.

Out of 1,307 locomotives, over 600 have self-cleaning front ends. By comparing two years before and after making this change we find the amount of coal per 1,000 ton-miles decreased nearly 3%, which I state merely to indicate that the self-cleaning feature has not increased the fuel consumption.

Delays on the road due to dumping cinders from the old style front ends are, of course, entirely eliminated, also the setting fire to engine truck packing from hot front end cinders.

There being no cinders to burn, the change has done away with burned and warped front end frames and doors, particularly where pressed steel shapes are used.

In changing the style of front ends we have not shortened up the extended front, which we believe would be of advantage in the way of obtaining better draft with still larger exhaust nozzles.

HIGH SPEED STEEL.—A topical discussion on High Speed Steel was opened by Mr. J. A. Carney, as follows:

The almost prohibitive cost of high speed steel makes one consider carefully whether or not it should be purchased for all classes of work, and especially for old machines which cannot tax the capacity of the cheaper self-hardening steels. When one figures that a tire lathe tool cost from $8 to $10, it looks like a lot of money. On the other hand, if we will take into consideration the slower speed, smaller output, time lost sharpening and dressing tools and the loss of material incident to dressing and sharpening, it will be seen that the cheaper tempering and self-hardening steels are too expensive to be considered. A case in question: A set of bolt cutter dies made of 10-cent tempering steel cost 21 cents for labor and 5 cents for material, total 26 cents, and cut 100 bolts before dressing. A set of similar cutters made of 75-cent high speed steel cost 37½ cents for material and 40 cents for labor, total cost 77½ cents, and cut 1,100 bolts before dressing. Enough tempering steel cutters to do the same work would have cost $2.86. This is what I mean when it is said we cannot afford to use low capacity steel.

The use of tool holders and smaller sizes of steel will effect great economies in the investment of high speed steel, and in one instance the introduction of tool holders reduced the number of pounds of steel required for a wheel lathe over 80% and instead of a tool 1x2 inches, 18 inches long, costing $7.87, a 1x1x8-in. tool, costing $1.87, is used and the tool holder does not wear out or break and costs 5 cents per pound, against 75 cents per pound for high speed steel.

Rosebit reamers can be tipped with high speed steel and increase their efficiency from 750 to 1,000%; in fact, a little ingenuity and thought will open up economies in the quantity of high speed steel that were never given a thought when 10-cent steel was used.

Larger section tools of high speed steel which have become too short can be hammered out into tools of smaller section with excellent results.

High speed steel has come to stay until some more efficient material is discovered, and while its price may make us question its economy, a second thought will convince us that we cannot afford to go back to the cheaper tool steels for heavy work, however good these may be in their class.

THE LATEST DEVELOPMENTS IN THE PHILADELPHIA MUNICIPAL SITUATION.

Alleged irregularities in Philadelphia filtration contracts led to the arrest of Select Councilman Frank H. Caven on June 13, and this action was followed by other interesting developments. Mr. Caven's hearing on June 15 may be summarized as follows: A document was presented in evidence in the nature of an agreement between James Caven and Frank Caven (defendant), trading as Jas. Caven & Son, of the first part, and Norcross & Edmunds, of the second part. This document was signed by all the parties, including Frank H. Caven, the defendant. It was virtually an agreement not to compete for filter sand and gravel sub-contracts about to be let by D. J. McNichol under his existing and expected city filter bed contracts, and contained a further agreement for a division of profits arising from the prospective sub-contracts. The examination showed that McNichol did sub-contract for filter sand with some of the parties to this agreement, but apparently it did not prove that the defendant was interested in the sub-contracts. Mr. Caven was held under bail for trial. To the surprise of many, it was learned during the examination that Mr. D. J. McNichol had only a 1-12 interest in the contracts in question, the remaining 11-12ths being equally divided, for some time, between Israel Durham, State Insurance Commissioner and head of the local political organization; John M Mack, a Philadelphia contractor, and Mrs. James P. McNichol. Mr. Mack withdrew some 18 months ago, and on the retirement of Mr. James P. McNichol as a select councilman and on or before his election as a State Senator, Mrs. McNichol's interests were transferred to Mr. McNichol.

Following the Caven hearing, Mayor Weaver ordered the seizure of the Torresdale and Belmont filtration plants, under construction by the D. J. McNichol interests. About this time Mr. John W. Hill, M. Am. Soc. C. E., Chief Engineer of the Bureau of Filtration, and Mr. Henry C. Hill, First Assistant Engineer, submitted their resignations. No reason for these resignations has been made public, further than a statement in Mr. H. C. Hill's letter that he desired to engage with his father "in what promises to be more profitable and congenial employment." Mr. John W. Hill's salary had recently been raised from $12,000 to $17,000 a year, on the recommendation of Mayor Weaver. On Tuesday, June 20 a warrant was issued and gave bail through M. Wood, of R. D. Wood & Co. On the s Mayor Weaver rescinded the $700,000 for sand at the Torresdale filter plant D. J. McNichol and associates.

On June 19 an investigating committee adversely on the character of the foundat of the Northeast Boulevard, work on w der a contract with D. J. McNichol was suspended some days ago. The committe that rotten rock had been used for the base.

On Tuesday, June 13, a councils commit ter an exciting meeting, referred the pr street railway ordinance repeal bills, outli our issue of June 15, to the city solicitor mediate report as to their legality, the vote being 15 to 11. The solicitor declared the proposed repeal bills legal, and on June 15 the committee just named recommended their passage. The bills were ordered printed and it is expected that they will come up for passage on June 29. Councils, it may be added, has reconsidered its vote to adjourn on June 15 for the summer.

The Hon. Elihu Root, ex-Secretary of War, and other attorneys from New York City are acting as counsel to Mayor Weaver.

NOTES FROM THE ENGINEERING COLLEGES.

STATE UNIVERSITY OF IOWA.—The School of Applied Science of the State University of Iowa has been reorganized into a college and the present director of the school, Prof. William G. Raymond, M. Am. Soc. C. E., has been made dean. A new fireproof building is being erected, and is expected to be in service before the end of this year. Contract has just been let for the building of a dam across the Iowa River below the University grounds. This dam, besides providing a sheet of slack water about two miles long on which the University borders, will provide power for the institution, and for experimental purposes, and will have constructed near one end a canal across which removable dams of various sections will be placed for the study of flow over such structures.

THE VESSEL TONNAGE MOVEMENT of the principal ports of the world—foreign trade tonnage entered and cleared—for the years named, was compiled in the Bureau of Statistics, Department of Commerce and Labor, from official sources. The figures represent mostly metric tons of 2,204.6 pounds:

Ports.	Year.	Entered.	Cleared.
Europe.		Tons.	Tons.
Great Britain:			
Cardiff	1903	4,988,907	8,190,240
Hull	1903	2,631,778	2,055,140
Liverpool	1903	7,817,050	6,682,568
London	1903	10,958,739	8,104,890
Tyne ports	1903	3,788,626	5,232,501
Glasgow	1903	1,560,432	2,736,624
Malta (Valetta)[1]	1903	3,594,274	3,580,994
Gibraltar	1903	3,896,623	3,872,445
Germany:			
Hamburg	1903	8,244,660	8,450,132
Bremen	1903	2,709,744	2,578,873
France:[2]			
Havre	1904	2,382,646	1,834,447
Bordeaux	1904	982,503	677,218
Dunkirk	1904	1,277,586	838,804
Marseille	1904	5,061,912	4,646,467
Belgium:			
Antwerp	1903	9,073,021	9,104,275
Netherlands:			
Rotterdam	1903	6,934,760	6,662,800
Italy:			
Genoa	1903	3,776,659	3,113,720
Russia:			
St. Petersb'g (Cronstadt)	1903	1,347,898	1,355,417
Odessa	1903	1,826,405	1,713,268
Riga	1903	1,111,033	1,121,849
Spain:			
Barcelona[3]	1903	1,860,713	1,374,099
Bilbao[3]	1903	2,060,817	2,134,503
America.[4]			
United States:			
New York	1904	9,235,524	8,700,590
Boston	1904	2,713,371	2,250,977
Philadelphia	1904	1,712,052	1,728,244
Baltimore	1904	2,246,713	1,280,274
New Orleans	1904	1,475,467	1,580,442
Puget Sound	1904	1,171,554	1,353,528
San Francisco	1904	876,090	1,014,804
Argentina:			
Buenos Aires	1902	3,389,254	3,104,208
Brazil:			
Rio de Janeiro[5]	1902	2,632,231	2,622,657
Asia.			
British colonies:			
Hongkong-Victoria[6]	1903	9,612,292	9,592,797
Singapore[7]	1903	6,011,257	5,980,762
Colombo[8]	1903	4,739,288	4,709,346
China:			
Shanghai	1903	6,179,554	6,162,851

Yokohama	1903	2,545,292	2,490,397
Nagasaki	1903	2,007,153	2,007,052
Kobe	1903	3,864,587	3,840,565
Moji	1903	3,577,758	3,567,916
Africa.			
Town[9]	1903	3,776,712	3,388,473
Oceania.			
Australia:			
Melbourne[10]	1903	3,252,702	3,234,588
Sydney[10]	1903	3,348,966	2,585,445

[1] Figures for the year ended March 31, 1904.
[2] With cargoes only.
[3] Figures include the tonnage of vessels engaged in the foreign trade calling at several ports in the course of the same voyage, the tonnage of such vessels being taken account of at the port of call.
[4] Year ended June 30.
[5] Foreign and coastwise.
[6] Exclusive of Chinese junks engaged in the foreign trade. The tonnage of these vessels entered and cleared in 1903 was 965,890 and 974,400, respectively.
[7] Exclusive of warships, transports, native craft and vessels under 50 tons, but inclusive of vessels engaged in trade between the Straits Settlements.
[8] Exclusive of the tonnage of vessels that called for the purpose of coaling and for orders only.
[9] Figures, so far as they relate to steam vessels, represent gross tonnage, and are inclusive of transports carrying stores, but exclusive of those carrying troops.
[10] Including interstate shipping.

Note.—The considerable differences between the figures of tonnage entered and cleared at most British ports are due mainly to the fact that vessels arriving in the foreign trade at one port, after discharging their cargo and receiving part of their return cargo, prior to starting on their return voyage, touch at some port, e. g., Cardiff, for coaling or supplementary cargo and receive their foreign clearance at this latter port.

AN IMPORTANT CONSOLIDATION of two large manufacturers of compressed air machinery and rock drills, namely, the Ingersoll-Sergeant Drill Co. and the Rand Drill Co., is announced. The title of the new company is the Ingersoll-Rand Co., which will operate under a New Jersey charter with $10,000,000 capital, half of which is preferred and half common stock. Each of the two companies was about 35 years old, the Ingersoll-Sergeant Co. being the larger of the two, its output perhaps being double the output of the Rand Co. The two companies had factories in seven different towns and cities. Factory changes will be made, but what the changes will be has not been announced. Changes will be made in the designs of drills and air compressors; for example, it has already been decided to apply the Ingersoll-Sergeant method of rotation to the Rand Little Giant drill. Thus the best features of the different patents owned by the two old companies will be applied to the machines to be made by the new company.

The officers of the new company are: W. L. Saunders, President; G. Doubleday, J. R. Rand, J. A. McCall, J. P. Grace and Geo. R. Elder, Vice-Presidents; G. A. Brainard, Secretary, and W. R. Grace, Treasurer. Mr. Saunders was president of the Ingersoll-Sergeant Co., and Mr. Rand was president of the Rand Co. For the present the offices of the two old companies will continue to be occupied; but later on the offices will be combined.

ELECTRIC TRACTION ON THE THREE-PHASE system is to be exploited in the United States by the Railway Electric Power Co., organized to control the American rights to the Ganz system, as developed by Ganz & Co., of Budapest and used on the Valtellina Ry. in Italy. The Board of directors of the Company is composed of John E. Borne, President of the Colonial Trust Co.; William L. Bull, of Edward Sweet & Co.; Henry Seligman, of J. & W. Seligman & Co.; Stephen Peabody; H. R. Duvall, of the Atchison, Topeka & Santa Fe R. R.; Leopold Wallach, of Wallach & Cook; Henry L. Sprague, of Stetson, Jennings & Russel; Gustav Lindenthal, M. Am. Soc. C. E., and Gustave Leve. Messrs, L. B. Stillwell, Electrical Director of the Interborough Rapid Transit Company, and Frank N. Waterman are the Consulting Engineers.

THE INSTALLATION OF THE BLOCK SYSTEM has been completed on the main line of the Southern Ry. from Washington, D. C., to Atlanta, Ga. The manual system is used and the signal towers are located about 2½ miles apart.

A LEGAL DECISION OF INTEREST to contractors and engineers has been rendered by Justice Anderson of the Supreme Court of the District of Columbia. In the bids recently opened for the construction of a dry dock at the New York Navy Yard, there was one by George B. Spearin, contractor, which was the lowest of the ten separate bids received for the work. The Bureau of Yards and Docks consequently gave Spearin the award. In going over his bid more carefully, Spearin found that he had made a mistake of $100,000 in totaling his bid and sought to have it corrected; this the department refused to do, but accepted his original proposal. Spearin refused to execute the contract in accordance with the amount in the original proposal, and the Navy Department undertook to declare the $25,000 check, which accompanied the bid for the dock, forfeited. Mr. Spearin then brought suit against Rear Admiral Mordecai T. Endicott, Chief of the Bureau of Yards and Docks, and Ellis H. Roberts, Treasurer of the United States. The object of the suit was to restrain Admiral Endicott from delivering the complainant's certified check for $25,000 to Treasurer Roberts, to restrain Mr. Roberts from receiving the check, and to have the same canceled and returned to Mr. Spearin. Demurrer was entered by the defendants, but Justice Anderson of the Supreme Court of the District of Columbia, signed an order overruling this demurrer. In an elaborate opinion filed in the case Justice Anderson granted the order prayed for, restraining Admiral Endicott from delivering the certified check to Treasurer Roberts; the Justice was notified by the attorneys for the government that although the decision was against them, the officials were satisfied with it, and, having concluded that his interpretation of the law was correct, they would carry the matter no further. In concluding his opinion Justice Anderson said:

> Since there can be no contract where the minds of the parties have not met, a mistake, even on one side, may be good ground in equity for relief, and the present case is believed to be one in which the interests of justice require that relief should be given.

As a consequence, the guaranty check will be returned to Mr. Spearin and a change made in the award of the contract for the construction of the dry dock.

RAILWAYS IN ALASKA are making steady progress with the development of the country, and one of the latest lines to be commenced is the Valdez, Copper River & Yukon Ry., which is to extend from Valdez, on Prince William Sound, north to the Copper River copper district. This district has extensive deposits of copper ores containing gold and silver. As there are no transportation facilities, however, and the deposits are very far from the coast, they have had no commercial value, but a company has now been organized to build a railway and develop the property. The total length of the line will be about 300 miles, and it is expected to complete the road from Valdez through Keystone Canyon and as far as Marshall Pass, 35 miles, this year. The Chief Engineer and General Manager is Mr. A. W. Swanitz, who was Chief Engineer of the Alaska Central Ry., described in our issue of Sept. 8, 1904. He sailed recently for Alaska with the first construction force for the new line.

A 108-FT. DERRICK BOOM is being used in the erection of the Scherzer bascule bridge over the Chicago River at Harrison St. The derrick has two masts, braced by back legs and connected at the top by a transverse timber. At the foot of one mast is pivoted a short boom, while at the foot of the other is pivoted the 108-ft. timber boom, stiffened by four truss rods carried over two rectangular strut frames. Some of the members handled by this boom weigh 14 tons. The derrick was designed and built by Jackson & Corbett, of Chicago, who are erecting the bridge.

PERSONALS.

Mr. R. O. Danenhower has been appointed City Engineer of Little Rock, Ark.

Mr. John H. Hudson, Jr., has joined the staff of W. R. Grace & Co., Lima, Peru.

Mr. C. S. Alverson has been appointed Superintendent of the Water Department of San Diego, Cal.

Mr. Ralph C. Soper, Engineering Aid in U. S. Reclamation Service, will report for duty to Mr. J. Ahern, Cody, Wyo.

Mr. Frank H. Brundage, Assistant Engineer in the U. S. Reclamation Service, has been directed to report to Mr. J. Ahern, Cody, Wyo.

Mr. W. A. Clement, for some time connected with the Engineering Department of the city of Toronto, Ont., has been appointed City Engineer of Vancouver, B. C.

Mr. Lewis E. Foster has been appointed Engineering Aid in the U. S. Reclamation Service and will report at Glendive, Mont., to assist in soil classification work.

Mr. Walter B. Freeman has been appointed Hydrographic Aid in the U. S. Reclamation Service, and has been assigned to duty under Mr. C. G. Babb, Browning, Mont.

Mr. William E. Dickinson, of New York City, has received an appointment as Assistant in the Department of Mechanical Engineering of the University of West Virginia.

Mr. Thomas F. Eastman, of San Francisco, Cal., has been appointed Engineering Aid in the U. S. Reclamation Service. He is a graduate of the University of California.

Mr. J. Y. Jewett, who has been engaged for some time as Cement Expert to the U. S. Reclamation Service has received a permanent appointment and began duty under it on June 9.

Mr. E. P. Lovell, Adjunct Professor of Civil Engineering at Columbia University, has been appointed Dean and Director of the Department of Civil Engineering of Cornell University.

Mr. Fred. W. Talbot, of Maine, has been appointed Hydrographic Aid in the U. S. Reclamation Service. He is a graduate of the Civil Engineering Department of the University of Maine.

William G. Raymond, M. Am. Soc. C. E., Dean of the College of Applied Science, State University of Iowa, has had the degree of Doctor of Laws conferred on him by Washington University, St. Louis, Mo.

Mr. John Findley Wallace, M. Am. Soc. C. E., Chief Engineer Isthmian Canal Commission, sailed June 16, from Colon to confer with Secretary Taft on Canal affairs and also to purchase materials.

Mr. E. W. Vernier, of Indiana, has been appointed Engineering Aid in the U. S. Reclamation Service, and has reported at Ft. Laramie, Wyo., to Mr. John E. Field. Mr. Vernier is a graduate of Purdue University.

Mr. Chas. A. G. Winther, for many years General Superintendent of the Chapman Valve Mfg. Co., of Indian Orchard, Mass., has accepted a similar position with the Roe Stephens Mfg. Co., of Detroit, Michigan.

Mr. Roy Bullen, of Massachusetts, has been appointed Engineering Aid in the U. S. Reclamation Service and has been assigned to duty in the West. He is a graduate of the Lawrence Scientific School of Harvard University.

Mr. H. L. Weber, for the past eleven years City Engineer of Richmond, Va., has resigned that position to become Chief Engineer of the Fort Wayne & Wabash Valley Interurban Ry., with headquarters at Fort Wayne, Ind.

Mr. Wm. A. Lamb, of Denver, Colo., has been appointed Engineering Aid in the U. S. Reclamation Service and will act as field assistant to Mr. H. C. Hinderlider. Mr. Lamb is a graduate of the Colorado State Agricultural College.

Mr. Sidney E. George, of New York, has received an appointment as Hydrographic Aid in the U. S. Reclamation Service and will be assigned to duty in the West. He is a graduate of the Civil Engineering Department of Cornell University.

Mr. I. F. White, formerly Engineer of Maintenance of Way of the Cincinnati, Hamilton & Dayton R. R., has been appointed Superintendent of the Northern and Southern Divisions with headquarters at Dayton, O., to succeed Mr. R. H. Bowron, promoted.

Mr. Alfred B. Mayhew, of Massachusetts, has been appointed an Engineering Aid in the U. S. Reclamation Service and will report at the Washington office for future assignment. He is a graduate of the Civil Engineering Department of Tufts College.

Mr. Chas. Francis de Nevers, M. Am. Soc. C. E., formerly General Manager of the Russo-American Steel Co., Mariopol, Siberia, has accepted the position of Consulting Engineer of the New Jersey Boiler Co., of Boonton, N. J., with offices at 95 Liberty St., New York City.

Mr. Harold N. Cross, of Exeter, N. H., has been appointed Assistant Engineer in the U. S. Reclamation Service and will report for duty to Mr. F. E. Weymouth, Glendive, Mont. Mr. Cross is a graduate of the Thayer School of Civil Engineering of Dartmouth College.

Mr. Carl R. Weitze, of Clinton, Mass., has been appointed Engineering Aid in the U. S. Reclamation Service and will report to Mr. C. W. Smith, on Roosevelt Dam, Arizona. Mr. Weitze is a graduate of Lawrence Scientific School of Harvard University, with the degree of C. E.

Mr. Clayton W. Bowles, of Orono, Me., has received an appointment as Engineering Aid in the U. S. Reclamation Service, and has been directed to report to Mr. F. E. Weymouth, Glendive, Mont. Mr. Bowles is a graduate of the Civil Engineering Department, class of 1905, of the University of Maine.

Mr. Wm. F. Martin, of Texas, has been appointed Hydrographic Aid in the U. S. Reclamation Service and will assist Mr. W. H. Clapp in hydrographic work at Los Angeles, Cal. Mr. Martin was graduated from the Sam Houston State Normal School at Huntsville, Tex., and from the University of Texas.

Mr. Andrew C. Cunningham, M. Am. Soc., C. E., Civil Engineer, U. S. Navy, has been detailed to act as Assistant to Rear Admiral M. T. Endicott, Chief of the Bureau of Yards and Docks. Mr. Cunningham recently has been in charge of the new construction work at the Naval Academy at Annapolis.

Mr. Leonard M. Cox, Civil Engineer, U. S. Navy, Supervising Engineer Steel Floating Dock, for Cavite, P. I., is now located temporarily at Solomon, Md., where he will be until the conclusion of the official tests of the U. S. Floating Dock Dewey. Mr. Cox, heretofore, has been stationed at Sparrows Point, Md.

Mr. E. E. Linthicum, of Anniston, Ala., who for the past five years has been Manager for the U. S. Cast Iron Pipe Co., at Anniston, Ala., has tendered his resignation to take effect as soon as his successor can be chosen. Mr. Linthicum resigns to accept the management of a new company which is controlled by capitalists of Atlanta, Ga.

Mr. Albert E. Wood, of Cleveland, O., has received an appointment as Engineering Aid in the U. S. Reclamation Service and will report to Mr. J. E. Field, Ft. Laramie, Wyo. Mr. Wood was graduated from Fayette Normal School with the degree of B. S., and later took a course in civil engineering in Case School of Applied Science, graduating this year.

Mr. Frederick A. Biggi, of New York City, has received an appointment as Engineering Aid in the U. S. Rerlamation Service, and will be engaged at present in the Washington office. Mr. Biggi was graduated from the Massachusetts Institute of Technology with the degree of C. E., and has been engaged in various capacities of surveying, drafting, etc., by the city of Boston.

Mr. Morris R. Sherrerd, M. Am. Soc. C. E., who has hitherto been Engineer and Superintendent of the Department of Water of Newark, N. J., has been appointed to the newly created office of Chief Engineer and City Surveyor at a salary of $7,500 per year. Mr. George Saugenbacher succeeds Mr. Sherrerd as head of the Water Department. Mr. Louis C. Dittler was appointed Chief Engineer of the Street Department.

Mr. P. W. Price, of Pennsylvania, has been appointed an Assistant Engineer in the U. S. Reclamation Service and will report at the Washington office. He was graduated from the Western University of Pennsylvania with the degree of C. E., and has had considerable experience in surveying for the Pennsylvania R. R., the Santa Fe Ry., Great Northern Ry., American Bridge Co., Northern Pacific R. R., Puget Sound Power Co., and Yakima Development Co.

Mr. A. W. Swanitz, who last year constructed the first 30 miles of the Alaska Central Ry., described in our issue of Sept. 8, 1904, has sold his interests to a Canadian syndicate, and has now undertaken the construction of the Valdez, Copper River & Yukon Ry., as Chief Engineer and General Manager, with headquarters at Valdez, Alaska. Mr. Swanitz sailed from Seattle last week with the first construction force. A note of this railway is given elsewhere.

Mr. Schuyler Hazard, M. Am. Soc. C. E., has resigned as Roadway Engineer, Southern Ry., at Birmingham, Ala., to accept a position as Resident Engineer of the New York Contracting Co., on the New Haven Improvements. He will be in charge of 6-tracking the Harlem River Branch of the New York, New Haven & Hartford R. R., from 129th Street, New York City, to New Rochelle, N. Y., and will have his headquarters at Westchester, Borough of the Bronx, New York City.

Mr. William M. Torrance has resigned his position as Assistant Engineer with the New York Central & Hudson River R. R., and is now Assistant Engineer with the Underwriters' Engineering & Construction Co., a new organization for contract work in reinforced concrete, of which Frank B. Gilbreth, M. Am. Soc. C. E., is President, and Prof. Lewis J. Johnson, of Harvard University, Consulting Engineer. The officers of the company are at 34 West 26th St., New York City.

Mr. Edward Buryee, of Arizona, has been appointed Cement Expert to the U. S. Reclamation Service and will remain in charge of the cement works at Roosevelt, Ariz. Mr. Buryee, who is a graduate of Rutgers College, has been connected with the U. S. Reclamation Service since April, 1903. Before that time he had been with the New Jersey Geodetic Survey; Assayer and Metallurgist with several smelting companies in New Mexico, Colorado and California; Superintending Chemist Montezuma Portland Cement Co., and Chemist California Portland Cement Co.

Obituary.

James Black, a civil engineer and inventor, with offices in the Bennett Building, New York City, was run over by an automoble and died June 16, in the J. Hood Wright Hospital, New York. Mr. Black, who was 54 years old, was interested in the Delver Cooperative Co., an electrical concern.

Richard S. Sayer, President of the Rider Ericsson Engine Co., of New York, and his wife were instantly killed June 15, in an automobile accident. Two young sons were also injured and will probably die. The party was in an automobile and while attempting to cross the Erie R. R., near Goshen, N. Y., were struck by a freight train.

Howard Scott Webb, M. Am. Inst. E. E., Professor of Electrical Engineering at the University of Maine, died June 12, from acute tuberculosis at the State Sanitarium at Hebron, Me. Professor Webb was graduated from the Mechanical Engineering Department of the University of Maine in 1887. He was an instructor in that department for several years, and afterwards spent two years in study at Cornell University and at the University of Chicago, securing the degree of E. E. from the latter institution. He was at the Schenectady plant of the General Electric Co., for a short time, and then returned to Orono, Me., to become head of the new electrical engineering department, when it was started some years ago.

George C. Woolard, Jun. Am. Soc. C. E., Engineer and Superintendent for Ambrose Stannard, in the construction of the new municipal building at Washington, D. C., died June 3, of endocarditis, at the George Washington University Hospital, Washington, D. C. Mr. Woolard formerly was connected with James Stewart & Co., and as Engineer and Superintendent for that concern he built the Westinghouse buildings at East Pittsburg, Pa., the Plaquemine Lock at Plaquemine, La., the plant of the Singer Mfg. Co., at St. Johns, Que., and 50 miles of the Southern Pacific R. R., after the Galveston Flood. He was also Superintendent of Construction of the Cedar Grove reservoir at Cedar Grove, N. J. He was about 27 years old.

Mr. James Mansergh, F. R. S., Past President of the Institution of Civil Engineers, and a member of the council of the Institution of Mechanical Engineers, died at London, England, on June 15. Mr. Mansergh had long been one of the foremost British engineers. A few years ago the city of Toronto, Ont., engaged him to go to that city and make a report on its water supply. He also made a report on methods of sewage disposal for Baltimore, Md., but did not visit that city. One of the most important of the works with which Mr. Mansergh has been connected of late is the new water supply for Birmingham, England, involving the construction of a number of masonry dams in Wales, a long aqueduct, a filtration plant and other accessories. Mr. Mansergh was elected to the Institution of Civil Engineers in 1859, transferred to full membership in 1873, and assumed the presidency in November, 1900. His practice for some years past was conducted under the firm name of James Mansergh & Sons. One of the latter, Mr. Ernest Lawson Mansergh, was admitted to full membership in the Institution of Civil Engineers in 1900.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN CHEMICAL SOCIETY.
June 22-24. Annual meeting at Buffalo, N. Y. Secy., W. A. Noyes, Washington, D. C.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 28, 29, 1905. Annual meeting at Atlantic City, N. J. Secy., Prof. M. S. Ketchum, Boulder, Colo.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 29-July 1. Annual meeting at Atlantic City, N. J. Secy., Prof. Edgar Marburg, Philadelphia, Pa.

PACIFIC COAST ENGINEERING CONGRESS.
June 29 to July 1. At Portland, Oregon. Otto von Geldern, San Francisco, Cal., or Milnor Roberts, Seattle, Wash.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
June 29 to July 1. Annual convention at Portland, Oregon. Secy., Milnor Roberts, Seattle, Wash.

LEAGUE OF AMERICAN MUNICIPALITIES.
August 23 to 25. Annual meeting at Toledo, O. Secy., J. McVicar, Des Moines, Ia.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
August 23 to 25, 1905. Annual convention at Erie, Pa. Secy., F. P. Foster, Corning, N. Y.

AMERICAN PUBLIC WORKS ASSOCIATION.
August 30, 31, 1905. Annual meeting at Chattanooga, Tenn. Secy., W. H. Flint, Chattanooga, Tenn.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Sept. 5 to 7. Annual meeting at Montreal, Canada. Secy., Geo. W. Tillson, Brooklyn, N. Y.

ROADMASTERS & MAINTENANCE OF WAY ASSOCIATION.
Sept. 12, 14. Annual meeting at Niagara Falls, N. Y. Secy., C. E. Jones, C., B & Q. Ry., Beardstown, Ill.

NEW ENGLAND WATER-WORKS ASSOCIATION.—An excursion to Attleboro, Mass., is contemplated for the June meeting, June 28, 1905. The pumping station and supply wells of Attleboro, and the large reinforced-concrete standpipe now being built there, will be visited. It is planned to leave Boston (South station) at 9 a. m., and spend seven hours in Attleboro, leaving that city at 4:29 for Boston. Secy., Willard Kent, Narragansett Pier, R. I.

PACIFIC COAST ENGINEERING CONGRESS.—As previously announced, this congress is to be held at Portland, Oregon, June 29 to July 3. In our issue of May 25 a partial list was given of the papers to be presented. In addition to those already announced, the following papers will be read: "The System of the Portland General Electric Co.," by F. G. Sykes, Gen. Supt. P. G. E. Co.; "U. S. Reclamation Service," by D. C. Henny. Consulting Engineer; "The Work of the Reclamation Service in Oregon," by John I. Whistler, District Engineer; "U. S. Reclamation Investigations in Washington," by T. A. Noble; "The Struggle for Water in the Great Cities of the United States," by Marsden Manson; "Subterranean Water as Found in the Valleys of California," by John Richards; "Engineering Progress in the Northwest," by Charles Evan Fowler; "The Design of Tall Chimneys of Reinforced Concrete," by George Cotner Mason; "The New Power Plant of the Olympia Light & Power Co. at Tumwater, Washington," by Edward W. Cummings.

APPALACHIAN ENGINEERING ASSOCIATION.—Pursuant to the call for an organization meeting at the office of Henry Mace Payne, Civil and Consulting Engineer, Williamson, W. Va., a representative body of engineers gathered at that place on Saturday, June 10th, and after considerable discussion regarding the proposed plans for an associtaion, the following organization was effected: President, F. W. Calloway, C. E. Williamson, W. Va.; Vice President, Joseph F. Kent, M. E., Wyt... Va.; Secretary, Dr. Henry M. Payne, C. E., Ph... D., Williamson, W. Va.; Treasurer, N. H. Mann... C. E., Pikeville, Ky. The committee on name repo... the name "Appalachian Engineering Association" ... manimously adopted. A committee consisting of ... S. C. L. Gaujot, W. C. Martin and R. H. Buchan... ap- pointed to draft a Constitution and By-Laws ... Association, to report at the next meeting, wh... be held at Dr. Payne's office on Saturday, Ju... at 3 p. m.

It was moved that all members joining the ... ation on or about July 22, and paying $3 initiati... and dues should be considered Charter members and ... un- til Jan. 1, 1906, and that all others joining s... ently should pay $5 entrance fee and the yearly du...

The regular routine business was then tran... and a list of about 30 charter members was s... The secretary was notified to send a report of this ... ing to the engineering journals and the leading news... and it is hoped by these means to make known the ... aniza- tion of the association to all the engineers and ... hnical men within its territory, which embraces North ... arolina and South Carolina, Tennessee, Kentucky, ... rginia, Maryland and West Virginia.

There will be one or two papers read at the July meeting and a large attendance is anticipated. Those desiring to become charter members should attend this meeting, or send their names and fee to the secretary.

AMERICAN SOCIETY FOR TESTING MATERIALS.—As announced some weeks ago, the eighth annual meeting of this society will be held at Atlantic City, N. J., June 29 to July 1, 1905, with headquarters at the Hotel Chalfonte. The Society for the Promotion of Engineering Education will hold its meeting at Atlantic City at the same time, and one joint session will take place, this being the session of Thursday evening, June 29.

The program of the meeting of the American Society for Testing Materials will include the following papers and reports: "The Testing Engineer," Presidential Address by C. B. Dudley; "A Course of Laboratory Instruction in Testing Materials," by Prof. W. K. Hatt; "A Course in Properties of Materials," by G. L. Chritensen; "Plan and Scope of the Proposed Investigation of Structural Materials under the auspices of the U. S. Geological Survey," by J. A. Holmes and R. L. Humphrey; "The Portland Cement Exhibit and the Results of Tests at the World's Fair, St. Louis, Mo.," by R. L. Humphrey; "Normal Consistency Tests of Neat Cement," by R. S. Greenman; "An Economical Mold for Forming Compressive Test Pieces for Concrete," by Clifford Richardson and C. N. Forrest; "Slow-Pulling Early-Stage Rotary Portland Cement vs. the Ordinary Early-strength-developing Product," by W. A. Aiken; "British Standard Specifications for Cement," by R. W. Lesley; "Impact Tests of Asphalt Paving Mixtures," by Clifford Richardson and C. N. Forrest; "Standard Specifications for Preservative Coatings for Steel," by C. B. Dudley, Robert Job, A. H. Sabin, Maximilian Toch and C. de Wyrall; "Proper Methods in Conducting Paint Tests," by G. W. Thompson; "Protection of Iron and Steel Structures by Means of Paper and Paint," by L. H. Barker; "What is the Best Method of Painting Steel Cars?" by F. P. Cheesman, G. W. Thompson and S. M. Evans; "Some Causes of Failure of Rails in Service," by Robert Job; "Influence of Methods of Piling Staybolt Iron on Vibratory Tests," by H. V. Wille; "Tests of Nickel Steel and Carbon Steel Under Combined Stresses," by E. L. Hancock; "A Comparison of Standard Methods of Testing Cast-Iron," by Richard Moldenke; "Hard Cast-Iron, the Theory of One of Its Causes," by Henry Souther; "The Thermite Process in American Practice," by E. Stuetz; "A Large Hydraulic Testing Machine for Uniform Loads," by R. A. Cummings; "Specifications for Cotton Tapes for Electrical Purposes," by R. D. de Wolf; "Rail Sections as Engineering Structures," by P. H. Dudley; Reports of committees on Standard Methods of Testing, Uniform Speed in Commercial Testing, Fireproofing Materials, Standard Specifications for Grading Structural Timber, Standard Specifications for Cement, Reinforced Concrete, Preservative Coatings for Iron and Steel, Standard Tests for Lubricants, Standard Specifications for Iron and Steel (embodying separate specifications for Structural steel for bridges, Steel rails, Steel castings, Steel axles and Steel forgings), Standard Specifications for Staybolts, Standard Specifications for Cast-Iron and Finished Castings (embodying separate specifications for Car wheels and Gray-iron castings), Magnetic Testing of Iron and Steel, Standard Tests of Road Materials, Boilers.

Besides these papers and reports, and the election of officers, etc., an important matter will come before the meeting in the form of proposed amendments to the constitution, changing (or rather severing) the relation between the society and the International Association for Testing Materials. The amendments provide that the membership dues shall be $5 annually, as at present, but this will not constitute the member a member of the International organizations, and the society will not contribute $1.50 per member to the latter. Any member of the society may, however, on payment of $1.50, become a member of the International Association.